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# PATENT NONUSE: ARE PATENT POOLS A POSSIBLE SOLUTION?

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# DEDICATION

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my lovely mom and dad,

for taking the time to teach me the value of humanity and education, and

for their continues support every day even from a long distance.

# PREFACE

Studies have depicted that the rate of unused patents comprises a high portion of patents in North America , Europe and Japan. The importance of the issue of nonuse is also highlighted within the literature on strategic patenting, IPR policy and innovation economics. Particularly, studies have identified a considerable share of strategic patents in the market for technology which are left unused due to pure strategic reasons. While such patents might generate strategic rents to their owner, they may have harmful consequences for the society if by blocking alternative solutions that other inventions provide; they hamper the possibility of better solutions. Moreover, the current literature has emphasized on the role of patent pools in dealing with potential issues such as excessive transaction cost caused by patent thickets and blocking patents (overlapping IPRs) that might hamper the use of patents in the market for technology. In fact, patent pools have emerged as policy tools facilitating technology commercialization and alleviating patent litigation among rivals holding overlapping IPRs. Accordingly, patent pools may favor the use of the pooled patents through decreasing licensing transaction cost and providing equal and non-discriminatory access of all the members and potential licensees to the pool's technology. This might be seen by companies involved in technology markets with excessive transaction cost and high IPR fragmentation as an opportunity to exploit their patents through participating in patent pools.Considering the importance of strategic patenting and patent nonuse from economics, social and technology point of view and the significant role of patent pools in facilitating technology commercialization this doctoral dissertation first provides a critical literature review on strategic patenting with the aim of identifying some future research paths for this stream of research. Moreover, it investigates the drivers of strategic non-use of patents with particular focus on unused play patents. Furthermore, it examines if participation intensity in patent pools by pool members explains their willingness to use the unexploited patents they hold outside the pool(non-pooled patents) through pool participation. It also investigates those characteristics of the patent pools that are associated to the willingness to use such patents through pool participation.

The **first chapter** presents the survey of the literature review titled “Strategic Patenting: A critical review and future research paths”. By employing an interdisciplinary approach to uncover theoretical gaps from across different domains I investigated three broad related issues : the drivers of strategic patenting, the welfare effect of strategic patenting and the solutions to tackle issues caused by strategic patenting and identified the key question that remained unexplored in each domain. I presented summaries of the critical findings of different studies which provide insights to (1) managerial decision making process for strategic use of patents and (2) assessing welfare effect of strategic patenting and (3) comprehensive solutions to tackle issues caused by strategic blocking patents and benchmark to assess their effectiveness. In addition I discussed future research paths and possibilities which could help to encourage future theory advances.

The **second chapter** titled "Why do they play? an empirical study on the antecedences of unused strategic patents" provides an empirical study on strategic non-use of patents. I investigate the drivers of unused strategic patents with particular focus on strategic patents intended to play. Using novel data from a large scale survey on European inventors of 22,533 EPO patents resident in Europe, USA, Japan and Israel (PatVal II), I find technological uncertainty and technological complexity as two technology environment specific factors that explain unused play patents.

In the **last chapter** titled "Patent non-use: are patent pools a possible solution?", I examine if patent pool participation can explain the willingness to use patents held by a pool member outside the pool (non-pooled patents). I also investigate those characteristics of the patent pools which are associated to the willingness to use non-pooled patents by a pool member through pool participation. Using PatVal II data as primary data and a considerably large database of patent pools in telecommunication and consumer electronics industries as secondary data, in this chapter I show that pool members participating more intensively in patent pools are more likely to be willing to use their non-pooled patents through pool participation. Furthermore, I show that pool licensors are more likely to be willing to use their non-pooled patents by participating in patent pools with higher level of technological complementarity to their own technology.

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# Chapter I

## Survey of the literature review

## Strategic Patenting: A critical review and future research paths

**Abstract**

Strategic patenting has attained considerable attention within the literature on strategic management of IPRs, public policy and innovation economics. Nevertheless, the existing knowledge on strategic patenting is characterized by persisting knowledge gaps and theoretical inconsistencies. By employing a critical literature review approach this paper reviews studies related to strategic patenting from 1984 to 2014. We limited our review to peer-reviewed Journal articles and highly acknowledged working papers from accredited sources and omitted books and book chapters to have a validated and influential source of knowledge for our review. With the aim of contributing to advancing theory and practice, each gap is identified and discussed in our study. Based on our analyses, we made suggestions for future research which could help to promote future theory development and provide pertinent material for policy and managerial decisions.

Keywords: strategic patenting, intellectual property right

## 1. Introduction

The main intention of the patent system is to temporarily protect the firm's invention. However, firms might also use their patent right for other so called "strategic" motives. In a definition presented by Arundel and Patel (2003), "strategic" motives refer to any intention beyond protecting an invention which aims to appropriate benefits from that invention. In fact, patents are not homogenous for their owner with respect to their function and value, and therefore generate different levels of additional profit to the companies. Such profits might go beyond original protection or monetary rent seeking purposes and provide the patent owner with strategic benefits.

Strategic patenting has been long discussed by the literature on strategic management of IPRs, innovation economy and public policy. In fact, studies have identified a considerable share of strategic patents in the market for technology (Cohen et al, 2001; Giuri and Torrisi, 2011; Jung and Walsh 2011; Blind et al., 2009). In principle, strategic patents are defined as those patents which are intended to be employed strategically, and therefore generate strategic rents for their owner (Giuri and Torrisi, 2011). "Strategic use of the patent system arises whenever firms leverage complementarities between patents to attain a strategic advantage over technological rivals. This is anticompetitive if the main aim and effect of strategic use of the patent system is to decrease the efficiency of rival firms' production." (Harhoff, et al., 2007). In practice such patents might be used in licensing or cross licensing deals, or even in an internal commercialization process by their owner; however the importance of such patents rises more when they encompass value and are left unused or they impede use of other inventions by blocking them. In fact, although such patents might have strategic values to their owner, their negative social and economic consequences are long discussed by the literature. This is first because a share of these patents is blocking alternative solutions that other inventions provide and therefore hamper the possibility of better solutions offered by those inventions. In other words, the novelty required to attain a patent right for a successive invention can be threaten by an existing patent that can block it (Scotchmer, 1991; Shapiro,2001; Jaffe and Lerner, 2004; Ziedonis, 2004; Grimpe and Hussinger,2008). Strategic use of patents with the intention of blocking the follow-on innovations decreases the speed of the innovation in the market and deviate its development path (Cohen, 2004). Companies often have to bear high penalty fees and accept obligatory royalty payments as a result of being litigated by market player which raise entry barriers to the technology market by filing strategic patents (Harhoff, et al., 2007). Patent races and slow diffusion of technology are also the consequences of strategic patenting.

Thus, patents as the most common and prominent IP protectors within the technology markets have got the greatest attention by the scholars, policy makers and practitioners dealing with strategic IP as they can provide certain monopoly power to their owners (Feldman,2008) and therefore hamper technology transfer within the market for technology to a high extend . In fact, strategic use of patents by one party not only creates impediments for technology transfer for others but also encourages them to strategically file patents in reaction to their rivals.

There are several motivations behind filing strategic patents which are discussed by the literature. A firm might protect its core technology from rival’s immitations by filing functionally similar substitutive patents around that in order to create a shielding boundary (Cohen, Nelson and Walsh, 2000). This type of patenting is more common in industries with discrete underlying technologies such as chemical and drug industry which aims to exclude rival from the market.

In complex technologies however the strategic incentives of the firms are different. In such technological fields firms might patent in order to obtain freedom to operate beyond the occupied technology or product space and avoid hold up problem (Grindley and Teece, 1997;Hall and Ziedonis 2001; Ziedonis 2004;Markman 2004; Blind, Edler, Frietcsh, and Schmoch 2006). This provides the firm with the possibility to access to complementary technologies and use patents as bargaining chips in cross licensing (licensing) agreements. In fact as negotiation tool patents are also utilized as compelling medium for co-operation and strategic alliances (Blind et al., 2009; Peeters & de La Pottelsberghe Potterie, 2006; Reitzig, 2004; Lerner, 1995).

Patents might also be used for signaling company's strength for potential infringement law suits particularly for larger companies that have patents very close to those of small companies and just patent to signal their power and not to use it in a product. In fact, in regards to possible patent infringement, the firms' patent position is vital since patents have a reactive function in co-operations and strategic alliances (Noel & Schankerman, 2006).

They might also be used to signal the visibility of the company regarding its performance within the market or in order to attract potential parties for R&D co-investment, strategic alliance, standardization and cross-licensing (Arundel, 2001; Long, 2002; Arora et al., 2001). Moreover, they can display the firm's earnings potential to investors (Rivette & Kline, 2000). Such signaling benefit is particularly important for small companies.

Nevertheless, the most important use of strategic patents for companies is to block other rival's inventions and prevent their entry into the market (Gilbert and Newbery, 1984; Grant, 1991). Indeed, the literature has categorized strategic patents into fence and play patents. Fence patens are those which are filed with the intention of preventing rivals from imitating the company's core technology (Cohen et al, 2000) which is more common in discrete technologies (Cohen et al, 2002;Davis, 2008; Jung, 2009). Cohen et al, (2002) define fence patents as those blocking patent which are not intended to be used in cross-licensing and licensing. By fencing, companies pursue a pure blocking approach which leads to the exclusion of the competitors. Blind, et al., (2006), refer to these patents as "offensive" patents.

Play patents that are more common in complex technologies are in general aimed for achieving freedom to operate and creating a reliable safeguard for future infringement litigations that might threat the company's inventions. In fact the most prominent role of these patents is to obtain bargaining power in cross-licensing agreements and negotiations (Cohen et al, 2000; Cohen et al 2002). As opposed to fence patents, these patents don't necessarily exclude the rivals from the market (Allison, Lemley, and Walker, 2009). Thus, although a firm might plan to block other opponents' inventions through practicing a play strategy, play strategy is not considered as a pure blocking tactic. Blind, et al., (2006), refer to these patents as "defensive" patents

In this paper we provide a critical review of the literature on strategic patenting. Strategic patenting in general falls within the broader literature stream of strategic management of intellectual property rights (Harhoff, et al., , 2007) which has been broadly defined as any possible strategic use of IPRs to gain competitive advantage, litigation power or market control(Fisher and Oberholzer-Gee, 2013; Meurer, 2003).

The first goal of this study is providing an interdisciplinary review that incorporates studies from strategy, innovation, management, economics and public policy. This goal is pursued by reviewing works conveying insights into (1) drivers of strategic patenting, the welfare effects of strategic patenting and the solutions to the issues caused by strategic blocking patents (2) providing the main discussions of the papers that address these issues. Our second goal is to identify the existing gaps. The literature has often investigated the drivers of strategic patenting, however there is a clear lack of a comprehensive framework that could explain the decision making process in strategic exploitation of patents. Moreover, the literature has long argued the negative welfare effect of strategic patenting; however, there exists a lack for a theory explaining the extent of this effect. Furthermore, although there have been some efforts in proposing some solutions for confronting issues caused by strategic blocking patents, yet there is no integrated and comprehensive framework proposed for these solutions. Furthermore, the effectiveness of these solutions is not examined. The third objective of this review is to provide suggestions for future research which could lead to clearer and more consistent theories concerning the threefold gap we discuss in this study.

## 2. Approach to the review

We undertook search of articles published between 1984 and 2014. We limited our review to Journal articles and highly acknowledged working papers written in English, dealing with strategy, innovation, management and public policy from accredited sources. Keyword searches were conducted on EBSCO Business Resource Complete and other source using keywords 'strategic patenting', 'blocking patent' and 'strategic management of IPRs'. In addition we conducted Boolean searches on several combinations of these keywords. In selecting the studies, we retained papers according to their relevance by title, abstract or through examination of the paper. Finally, with the aim of identifying those studies which might have been missed we did targeted searches of those journals that have a heavier concentration on the abovementioned topics in the EBSCO and Emerald database. With the aim of contributing to advancing theory and practice, each gap is identified and discussed in our study. Based on our analyses, we made suggestions for future research which could help to promote future theory development and provide pertinent material for policy and managerial decisions that executive and managers have to make in dealing with strategic exploitation of patents.

## 3. Literature review

### *3.1 Drivers of strategic patenting*

There is limited number of studies within the exiting body of the literature that have the drivers of strategic patenting. Among these drivers, firm-specific characteristics are one of the most studied factors. A number of studies have examined the link between firm size as a firm-specific factor and strategic use of patents (Hall and Ziedonis 2001; Blind, Edler, Frietsch and Schmoch ,2006 ;Giuri, et al, 2007;Motohashi, 2008;Jung 2009; Jung and Walsh 2010) showing the importance and higher share of strategic patents for larger firms comparing to smaller ones. In fact, strategic patenting is found to be positively related to the size of the firm. Possessing valuable downstream assets and capital intensity are other firm-specific characteristic argued by Jung (2009) to be positively associated to defensive strategic patenting. Moreover, Jung and Walsh (2010) found that technological maturity as a technology environment characteristic is negatively associated to the rate of strategic patents on account of the lower uncertainty associated to general characteristics of mature technologies. As another technology environment characteristic, Torrisi et al, (2014) found that the presence of one competitor for the patent is positively associated with strategic use of patents implying that, firm reliance on patents either to guarantee the firm's freedom to operate through licensing and cross-licensing or to shield their product or process innovation is more likely in the presence of competitors. They also find that a large number of competitors (intense technological competition) spur investments in patent fences. As another technology environment factor they also found that technological complexity is positively associated to strategic patenting.

### *3.2 Welfare effects of strategic patenting*

Various concerns have been raised by different studies regarding the weakening relation between the private and social value of patents, considering the patenting explosion and their diverse strategic exploitations (Hall and Ziedonis, 2001; Boldrin and Levine, 2005; Bessen and Meurer, 2008). By reviewing the literature, two different arguments can be obtained from the studies evaluating how a company's strategic behavior affected by the fragmentation of intellectual property rights and the existence of overlapping patents consequently impact the social and economic welfare.

The first stream of the studies focusing on strategic patenting (Levin, Klevorick, Nelson, & Winter, 1987; Bessen and Hunt, 2007), and patent proliferation (Hall and Ziedonis, 2001; Ziedonis, 2004; Lemley and Shapiro, 2005) argue that companies expand the size of their portfolio in response to fragmentation of IP rights by adapting an aggressive patenting approach or through M&As (patent portfolio acquisitions). In fact, strategic use of patents is considered as one of the most significant drivers for forming large patent portfolios by firms in a number of industries (Cohen, Nelson and Walsh, 2000; Hall & Ziedonis, 2001; Bessen & Hunt, 2004). Through studying the software sector in the U.S., Noel and Schankerman (2013) argue that R&D activities and patenting rate increase as patent rights fragmentation upsurges. This implies that patent accumulation is more important for resolving IP wars when there is higher number of patent holders (Noel and Schankerman, 2013). Furthermore, as valuable assets patent portfolios can be used strategically to provide the firm with possibility to collude on anticompetitive deals. For instance, Grindley and Teece (1997) and Hall and Ziedonis (2001), investigated how patent portfolios can be utilized as bargaining tools within the semiconductor industry. Moreover, some studies have shown that the strategies companies use for patenting are influenced by their patent portfolio characteristics (Blind, Cremers and Mueller, 2009).

According to Blind et al., (2009) the average for the citations by patent portfolio increases with the intensity of use of patents in order to obtain a protection objective, however it declines when strategic motives such as blocking and cross-licensing increases. They also postulated that when offensive blocking is an important reason for patenting, it is more probable that a company's portfolio receives opposition. In a study by Grimpe and Hussinger (2008) on 479 European Merger and Acquisitions, patent portfolios encompassing blocking potential are found to be acquired at a considerable fee.  There are a couple of reasons behind the necessity and usefulness of such technology acquisition such as obtaining those patents that are blocking the company's current R&D or eliminating a threatening patent fence. Moreover, acquisition of potential blocking patents might leverage the strategic position of a firm within the market since it can raise barriers to entry for potential entrants and built patent fences. Therefore, for protecting their investments on research and developments, companies opt for controling over a portfolio that encompasses blocking patents of significant value (Grimpe and Hussinger, 2008).

On the contrary to this line of research, the other stream of the studies argue that such technology markets are characterized by patent thickets (Shapiro, 2001; Lemley and Shapiro, 2007) patent holdup (Lemley and Shapiro, 2005), and the tragedy of anticommons (Heller and Eisenberg, 1998) which discourage investment in innovation and as a result decrease the rate of patenting by firms.

Patent thickets are broadly defined as "a dense web of overlapping intellectual property rights that a company must hack its way through in order to actually commercialize new technology" (Shapiro, 2001).  Patent thickets occur in technology fields with considerable overlap of IP rights (Shapiro, 2001) where patents can block other inventions which can be resolved only by bearing considerable bargaining costs (Heller and Eisenberg, 1998; von Graevenitz et al., 2011). It is believed that most patents filed in complex technological fields are of dubious value (Jaffe and Lerner, 2004).Furthermore, there is skepticism about the contribution of these patents to technological progress (Bessen and Maskin, 2006). Scholars raise concerns that cumulative innovation in ICT might be stifled by patent thickets with many low quality patents having a blocking capacity.  In fact, Innovation can be dispirited when blocking patents prevent the use of other's technology. Moreover, as a result of blocking other firms' inventions, the interoperability between different companies and their own technologies would be prevented. Moreover, due to the overlap of the patent rights caused by the vague IP right boundaries, resolutions with the technology market become more complex and the probability of intentional or unintentional infringement increases (Bessen and Meurer, 2008; Thumm, 2005).

Such technological environment provides opportunities for patent trolls (or sharks), who are patent right holders that  try to hide their patent portfolios with the intention of being infringed and therefor earn money by suing others  (Henkel and Reitzig, 2008; Merges, 2009; Reitzig et al., 2010). Therefore, although patent trolls might claim to have a technology licensing business model they are in fact involved in litigation activities.

"The Tragedy of Anticommons" also explains why valuable patents are under-utilized with the owners of the inventions blocking each other from exploiting their patents (Heller and Eisenberg, 1998). This is considered as a type of coordination breakdown, where several IPR holders are preventing each other from using a single resource (invention) since they all own it (Heller, 1998). Patent hold-ups are also discussed as another negative effect of strategic patenting (Lemley and Shapiro, 2005). A barrier, which holds up a company which is threaten by blocking patents is referred to as "hold up" which is in fact an abusage of patent right. Holdups mostly happen when companies make heavy sunk investments into specific technologies.

It is worth mentioning however that within this line of the literature there are few studies which provide conflicting arguments. For example von Graevenitz et al. (2008) find that the density of patent thickets which can threaten a firm's patent applications to get blocked, positively affects a firm's patenting activity.

### *3.3 Solutions to the issues caused by strategic blocking patents*

As discussed cross licensing, patent pools and compulsory licensing are proposed by the literature as the solutions to issues such as excessive transition cost generated by overlapping IPRs or the firm's anti-competitive behaviors. In 1995, the U.S. Department of Justice and U.S. Federal Trade Commission issued its "Antitrust Guidelines for the Licensing of Intellectual Property," which explicitly noted, "cross-licensing and pooling arrangements may provide pro-competitive benefits." "Portfolio cross licenses and patent pools can help solve the problems created by these overlapping patent rights, or patent thicket, by reducing transaction costs for licensees while preserving the financial incentives for inventors to commercialize their existing innovations and undertake new, potentially patentable research and development"(Shapiro, 2001).

An agreement according to which two or more parties grant a license to each other, in order to exploit the prior-art claimed in one or more of the patents each own is referred to as cross-licensing (Shapiro, 2001). Cross-licensing is particularly common for cumulative industries with complex technologies in which the likelihood of holding all patents required for a product by a single firm is very low. According to Giuri and Torrisi (2010) technological complexity as technology characteristics and cumulativeness and overlapping claims as patent characteristics have a substantial role in cross-licensing suggesting that cross-licensing can be useful for patent right holders in order to reduce transaction costs.

Moreover, the current debate within the literature has concentrated on the role of patent pools as a solution to the issue of patent thickets and overlapping IPRs. Kelin (1997) defines patent pool as "…the aggregation of intellectual property rights which are the subject of cross licensing, whether they are transferred directly by patentee to licensee or through some medium, such as a joint venture, set up specifically to administer the patent pool". Merges (1999), also defines a patent pool as: "A patent pool is an arrangement among multiple patent holders to aggregate their patents. A typical pool makes all pooled patents available to each member of the pool. Pools also usually offer standard licensing terms to licensees who are not members of the pool. In addition, the typical patent pool allocates a portion of the licensing fees to each member according to a pre-set formula or procedure."

Patent pools as a solution were initially proposed by Merges (1999), Shapiro (2001), and the U.S. Patent and Trademark Office by Clark, Piccolo, Stanton, and Tyson (2001), where for-profit firms share patent rights with one another and third parties, providing that the relationship between pool patents is complementary and not substitutive. As a matter of fact, patents are in complementary relationship with each other if by amassing them jointly in a single patent portfolio they would gain additional values. In fact, in dealing with excessive transaction costs participation in patent pools with mostly complementary patents is of more benefit for firms engaged in industries with technological complexity comparing to those involved in industries with discrete underlying technologies.

In fact, there are benefits associated to patent pools composed of mostly complementary patents in dealing with excessive transaction cost discussed within the literature. The most emphasized benefit is decreasing the licensing transaction costs derived from overlapping patent rights (Merges,1999;Clark, Piccolo, Stanton, and Tyson, 2001). Patent pools reduce the risk of litigation and disputes between licensors which leads to reduction in cost, time and uncertainty about IPRs. Moreover, patent pools eliminate the need for one-to-one licensing agreements and therefore not only reduce the cost, time and resources that should be dedicated to single licensing agreements but also decrease the risk of hold ups(Clark, Piccolo, Stanton, and Tyson, 2001), the so called "one- stop shopping" advantage[1]. Patent pools also provide their members with equal access to the pool's technology which escalates the patents commercial potential (Sung and Pelto, 1998). Providing equal access of the licensors to all potential licensees is another benefit associated to the patent pools (Bekkers, Iversen, and Blind, 2006). Furthermore, patent pool can also defuse information regarding invention developed by licensors which are not still patented (Merges, 1999), that can lower the likelihood of working on overlapping inventions which leads to accumulation of blocking patents and in extreme case patent thickets.

Therefore, the transaction cost can be reduced through patent pools by providing a single access-point that helps lowering searching cost, time and uncertainty, and increase transparency and accelerated and equal access to the firm's technology and potential licensees and eliminating creation of overlapping IPRs that are sources of transaction cost elevation (Bekkers, Iversen, and Blind, 2006).

Enhancing the competition which brings about pro-competitiveness is another benefit associated to patent pools consisting of mostly complementary patents that can reduce anti- competitive behavior among licensors. As pooled patents become more complementary patent pools tend to be more pro-competitive (Choi, 2010). Vakili (2012) in a study on MPEG-2 patent pool argues that the competition among pool members can be increased as a result of the lower barriers to entry provided by the pool which invite new entrants into the technological space. Therefore, patent pools comprising mostly complementary patents reduces the rate of strategic patenting to a considerable extent as they increase competitiveness and reduce strategic and anticompetitive behaviors among their members (Lampe and Moser, 2014).

Nevertheless, the role of patent pools in lessening the licensing transaction cost for companies involved in industries with complex technologies appears to be more significant as compared to those with discrete underlying technologies, since the fragmentation of IPRs and technology interdependencies causing excessive transaction costs is higher in these industries. Furthermore, the number of patent pool in complex technological fields is significantly higher as compared to

1 US Patent and Trademark Office, "USPTO issues white paper on patent pooling", Jan. 19, 2001.

[2] David A. Hounshell & John k. smith, JR., Science and corporate strategy: DU PONT R&D, 1902-1980 at 200

discrete ones. For instance, according to Merges (1996) in United States radio, aircraft, and automobile are examples of complex technologies which are developed based on patent pools. There are several other industries with complex technologies such as telecommunication and consumer electronics that are relying heavily on patent pools in developing technological standards.

The potential positive ex-ante and ex-post influence of patent pools on companies' innovation activities and technology commercialization is limited to the pool composed of mostly complementary patents. Patent pools can also have negative impacts on technology and innovation development and commercialization when they include patents with substitute relationships. As a matter of fact, by restricting the potential competitors' and new entrants access to the pool's technology, such patent pools encourage blocking activities by the pool licensors. Even creating the work-around the pool's technology would be tremendously hard due to the extent and the scope of such pools (Saunders, 2002).

Anti-competitive behaviors are therefore quite common among the licensors which in fact utilize the pool as a price-fixing mechanism, obliging the licensees to bear royalty fees for patents that normally they will not select, imposing restriction to outsiders who hold patents which substitute the patents included in the pool, restraining rivalry in downstream products which comprise the pooled patents or in other markets that are somehow linked to those, confining the accessibility of patents that are technically or economically necessary for those other standards; and eradicating inducements for follow on innovations (Bekkers, Iversen, and Blind, 2006).

Therefore, the potential welfare effect of patent pools will be positive if patents have a complementary relationship and will be negative if patents have a substitutive relationship (Shapiro, 2001). The welfare impact of patent pools is indeed studied through some models concerning their pro-competitive and anti-competitive impacts. The first model is presented by Lerner and Tirole (2003) through which necessary and sufficient condition for a pool is provided in order to increase welfare. This model is extended in a number of directions to convey an analysis of various patent pool-related issues including the external test evaluation which inhibits substitute patents to be included in a patent pool, the inducement of the firms engaged in a pool to do inventions around each other patents and the underlying principle meant for the provision of future-related patents' automatic transfer to the pool, Choi(2010) developed a model on the basis of the Lerner and Tirole (2003) framework which captures the full range of relationships between patents including perfectly substitutable and perfectly complementary. According to his model, the public policy scope is impacted by the relationship between the patent pool patents. Hence, when the relationship between pool patents are rather complementary patent pools turn to be pro-competitive. This implies that private and public enticements in forming such pools are perfectly aligned. On the contrary, when the relationship between the pool patents is substitutive the pool turns to be anti-competitive. This implies incongruities between public and social policies in the process of forming the patent pool.

Compulsory licensing is also discussed as another possible way in order to prevent strategic patenting. Compulsory licensing is purposed as a legislative way to facilitate the external commercialization of patents. Although, such provision seems to be useful Yosick(2001), argues that compulsory licensing is rarely employed in some major countries such as United States . He argues that the use of compulsory licensing is in general rejected by the courts except for some cases of remedy of antitrust violations and therefore there has been a strong opposition in Congress against the proposed comprehensive compulsory licensing legislation. Compulsory licensing is indeed a way to increase the social welfare when the patented invention is not used or is not available in the United States or when a new invention is getting blocked by the previous patent .In the case of  strategic non-use of the patented invention compulsory licensing makes the invention available to the public and at the same time produces some royalties for the patent owner and in the case of pure blocking actions, bargaining deadlocks will be resolved through obliging the prior patent owner to accept to deal with the improver through either the threat or the implementation of a compulsory license(Yosick,2001). Therefore considering a comprehensive compulsory licensing legislation as an addition to the patent system would be advantageous particularly as a way to increase the use of technology.

## 4. Conceptual issues

### *4.1 Strategic decision making*

Despite the relatively rich body of the literature on strategic patenting, we lack a comprehensive theory concerning the decision making process for utilizing patents strategically. The literature on strategic patenting has discussed some patent, firm and technology specific factors explaining the strategic use of patents (Hall and Ziedonis, 2001; Blind, Edler, Frietsch and Schmoch ,2006 ;Giuri, et al, 2007;Motohashi, 2008;Jung, 2009; Jung and Walsh, 2011;Torrisi et al, 2014). However, while these studies provide some insights on some drivers of strategic patenting, they don't provide a clear framework for the firms' decision making process in strategic exploitation of their patents. Table 1 presents the summaries of the studies providing explanations for why companies rely on strategic patenting

**Table 1 Drivers of strategic patenting**

| ***Factors explaining companies' reliance on strategic patenting*** | | **Study** |
|---|---|---|
| Patent-specific characteristics | Strong patent effectiveness | Jung and Walsh (2010) |
| | Firm size | Jung(2009), Giuri and Torrisi (2011), Hall and Ziedonis (2001), Blind et al., (2006), & Giuri, et al., (2007), Motohashi (2008), Jung (2009),& Jung and Walsh (2010) |
| Firm-specific characteristics | Large size of technological assets | Jung (2009), Jung and Walsh (2010) |
| | Possessing valuable downstream assets | Jung (2009), Jung and Walsh (2010) |
| | Capital intensity | Jung (2009), Jung and Walsh (2010) |
| Technology Environment-characteristics | Technology Maturity | Jung (2009), Jung and Walsh (2010) |
| | Technological Complexity | Torrisi et al, (2014) |
| | Intensity of competition | Torrisi et al, (2014) |

*4.2 Assessing the welfare effects of strategic patenting*

There has been considerable dependence on "Transaction Cost Economy" theory in explaining the negative welfare outcomes of strategic patenting. Based on this theory, it has been argued that strategic patents that cause blocking positions and create dense webs of overlapping intellectual property rights raise the transaction cost within the market for technology that ultimately impede the patents rightholdrs from using their patents (Shapiro, 2001; Lemley and Shapiro, 2007). Heller and Eisenberg (1998) refer to this effect as "The Tragedy of

Anticommons" where valuable patents are under-utilized where several IPR holders are preventing each other from using a single resource (invention) since they all own it (Heller, 1998). Patent hold-ups are also discussed as another negative consequence of strategic patenting (Lemley and Shapiro, 2005). A barrier, which holds up a company which is threaten by blocking patents is referred to as "hold up".

Although these studies provide some explanations for the welfare outcomes of strategic patenting, there is a clear lake for a comprehensive guidance for the assessment of the welfare effect of strategic patenting. In fact, while these studies provide insights on consequences of strategic patenting they provide little guidance on to what extent strategic patenting affects the social and economic welfare. Table 2 presents the main studies providing explanation for welfare effects of strategic patenting.

**Table 2 Welfare effect of strategic patenting**

| Main Them | Author(s) | Type |
|---|---|---|
| **Patent Thickets** | Shapiro (2001) | Theoretical |
| | Lemley and Shapiro (2007) | Empirical |
| **Patent holdups** | Lemley and Shapiro (2005) | Empirical |
| **Tragedy of Anticommons** | Heller and Eisenberg (1998) | Theoretical |

*4.3. The extent and the efficiency of the solutions*

Due to the significance of the negative welfare impact of strategic patenting from a public policy and economic perspective some studies have proposed ex-ante or ex-post solutions to this issue that leads either to reducing the strategic behavior within the market for technology and as a result decreasing the rate of strategic patenting (ex-ante) or to facilitate technology transfer through mechanism that lower the transaction cost among firms (ex-post). Accordingly, relying on TCE theory the literature has emphasized on the role of cross licensing and more importantly patent pools of complementary patents (vs. substitutive patents) as mechanisms that can deal with potential issues such as excessive transaction cost caused by patent thickets and blocking patents (e.g. Carlson, 1999; Shapiro, 2001) which hampers the use of inventions.

Cross-licensing is discussed as a coordination mechanism that can moderate the litigation costs for the owners of overlapping patents by providing them with the possibility to grant their intellectual property right to each other and facilitate technology transfer among parties through lowering transaction cost. Patent pools are defined as "[…] an agreement between two or more patent owners to license one or more of their patents to one another or third parties" (USPTO, 2000). Patent pools can lower the rate of blocking patents in the market for technology either by intensifying the rate of use of blocking patents which are included in the patent pool by decreasing the transaction cost (Merges, 1999) and providing equal and non-discriminatory access of all the members and potential licensees to the pool's technology (Sung and Pelto, 1998; Bekkers, Iversen, and Blind, 2006)- ex-post effect- or by preventing strategic behaviors by the pool members (Vakili 2012;Lampe and Moser, 2014) and decreasing the probability of working on overlapping inventions (Merges, 1999) -ex-ante effect-. Relying on "Property Rights Theory", Compulsory licensing is also discussed as one possible way to prevent strategic patenting (Yosick,2001; Cornides ,2007; Reichman , 2009). Compulsory licensing is purposed as a legislative ex-post approach to increase the rate of external use of patents. Although, such provision seems to be useful, Yosick(2001), argues that compulsory licensing is rarely employed in United States .

While the ex-post solutions rely mostly on TCE and Property right theory, the ex-ante mechanism explanation relies mainly on competition theory. Moreover, although these theories provide some explanations for the solution purposed to the issues generated by overlapping and strategic blocking patents, there exists a lake of an integrated framework that could explain a comprehensive solution mechanism. Moreover, there is a clear lack for studies investigating the extent to which these mechanisms can tackle the issue. Table 3 presents the summaries of the solutions for issues caused by strategic blocking patents by different studies.

**Table 3 Summary of solutions proposed to tackle issues caused by strategic blocking patenting**

| Studies | Proposed solution | Type | Theory employed |
|---|---|---|---|
| Shapiro (2001) | Cross licensing | Ex-post | Transaction Cost Economy (TCE) |
| Shapiro (2001), Merges (1999),Sung and Pelto, 1998, Bekkers, Iversen, and Blind, 2006, Lerner and Tirole (2003), Choi (2010) | Patent pool | Ex-post | Transaction Cost Economy (TCE) |
| Vakili (2012),Lampe and Moser (2014) | Patent pool | Ex-ante | Competition Theory |
| Yosick(2001), Reichman (2009), Cornides (2007) | Compulsory licensing | Ex-post | Property Right Theory(PRT) |

## 5. Suggestions for future research

Through this review we identified three main gaps within the literature on strategic patenting. Bellow, we further discuss future research possibilities for each gap.

### *5.1 Strategic decision making process*

The review of the literature on strategic patenting shows that although there have been some efforts to investigate the antecedences of strategic patenting, to date no integrated framework has been presented that can explain a firm's decision making process in exploiting a patent strategically. In other words while some studies have identified factors explaining strategic patenting no study has investigated the firm's process of decision making which leads to strategic exploitation of an invention. Future, research is needed to provide a decision step model, which could be based on a cost and benefit analysis that incorporates strategic rents and associated trade-offs with strategic use/nonuse of an invention. Moreover, future research could provide a theoretical framework that integrates resource base view, transaction cost economy and property rights theory together in order to provide a comprehensive strategic decision making framework that incorporates the most relevant components explaining strategic patenting identified by the literature. While the decision process to use an own invention strategically is interesting to study, there is also a further room for investigating the decision for strategic acquisition of other's patents particularly within a cost and benefit analysis framework. Furthermore, as the motivations for patenting vary across different technological fields(Cohen et al, 2000; Cohen et al 2002), the process of decision making to patent an invention for strategic purposes might have also significant differences which would be interesting to explore.

### *5.2 Assessing the welfare effect of strategic patenting*

While the literature review shows conflicting arguments raised by different studies regarding the welfare impacts of strategic patenting, there is a clear lack of theoretical and empirical studies investigating the extent to which strategic patenting might affect social and economic welfare. Such assessment is important not only from a policy perspective, but also from a managerial perspective since tackling with the social and economic issues caused by pure strategic exploitation of inventions by companies, requires also a within-firm awareness and practices. Particularly, welfare models could be developed that aim to address the mutual risks and costs associated to strategic use of patenting for parties contributing to the same technological space. Since the generalizability of such models might be questionable, the context specification considerations would be crucial in developing a more precise model. A context-specific model for assessing the welfare effect of strategic patenting however, could integrate managerial, social and economic components together in order to come up with a more comprehensive benchmark. Furthermore, the welfare effect assessment of strategic patent acquisition is also a relatively unexplored area for future research.

### *5.3.The extent and the effectiveness of the proposed solutions*

The review of the literature reveals solutions proposed by today to tackle issues caused by strategic blocking patents such as excessive transaction cost and nonuse of resources. While there are no integrated solutions suggested to date to these issues, there have been no efforts in assessing the effectiveness of each solution. However, although, different solutions might have various underlying mechanisms in tackling the issue, they ultimately have the same goal. This creates an opportunity to think of designing a more cohesive resolution framework. More importantly, understanding the effectiveness of each solution requires further research dedicated to investigation of the extent to which mechanisms such as patent pools can decrease the transaction cost. This would be feasible for example by examining the effect of patent pools on the rate of facilitation of technology commercialization. Some solutions such as compulsory licensing seem to be not favorable by firms and even some policy makers. Therefore, further studies are needed to examine solutions that could provide superior alternatives to compulsory licensing.

## 6. Conclusion

The strategic use of patents has become a central topic within the strategic management of IPRs filed. Strategic patenting literature is characterized by approaches that have bridged economic and management theories, management practices and public policy. However, advances in the strategic patenting literature over the last two decades and diverse observations by senior scholars steadily show that the literature on the strategic management of IPRs presently shows some discrepancies, and persevering knowledge gaps.

In this study we employed an interdisciplinary approach to uncover theoretical gaps from across different domains. Three broad issues were investigated: the drivers for strategic patenting, the welfare effect of strategic patenting and the solutions to tackle issues caused by strategic patenting. The main arguments in each theme were reviewed and the key question that remained unexplored was identified in each domain. We presented summaries of the critical findings of different studies which provide insights to (1) managerial decision making process for strategic use of patents and (2) assessing welfare effect of strategic patenting and (3) comprehensive solutions to tackle issues caused by strategic blocking patents and benchmark to assess their effectiveness. In addition we discussed future research paths and possibilities which could help to encourage future theory advances.

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# Chapter II

## Why do they play? an empirical study on the antecedences of unused strategic patents

**Abstract**

Strategic patenting has been long discussed within the literature on strategic management of IPRs, innovation economy and public policy. Particularly, studies have identified a considerable share of strategic patents in the market for technology which are left unused due to pure strategic reasons. While such patents might generate strategic rents to their owner, they may have harmful consequences for the society if by blocking alternative solutions that other inventions provide they hamper the possibility of better solutions. Using a novel database of inventors (PatVal II), this study investigates the drivers of unused strategic patents. We focus our attention on strategic patents intended to play. We find technological uncertainty and technological complexity as two technology environement specific factors that drive unused play patents. This study contributes to the literature on strategic management of intellectual property rights and public policy by identifying new determinants of unused strategic patents.

Keywords: Strategic patenting, play patents, patent nonuse

## 1- Introduction

Strategic patenting has been long discussed within the literature on strategic management of IPRs, innovation economy and public policy. Studies have identified a considerable share of strategic patents in the market for technology which are left unused (Giuri and Torrisi, 2011, Jung 2009, Jung and Walsh 2011). Although a share of these patents is not used since they might have no value (Rivette and Kline 2000), the importance of the issue of nonuse of these patents raises when they encompass value and are left unused or they are blocking the use of another valuable invention.

Strategic patents are defined as patents intended for strategic purposes and therefore will be basically left unused if they provide their owners with strategic rents (Giuri and Torrisi, 2011).According to Harhoff, et al., (2007) “Strategic use of the patent system arises whenever firms leverage complementarities between patents to attain a strategic advantage over technological rivals. This is anticompetitive if the main aim and effect of strategic use of the patent system is to decrease the efficiency of rival firms’ production.”

In general, there exists several strategic motives behind developing an invention discussed by the literature, however not necessarily all these motives will result in unused strategic patents.

Moreover, these motivations vary across different technological fields and therefore might generate different shares of unused patents across different industries.

As for industries relying on complex technologies such as semiconductor or telecommunication industry , the literature has discussed strategic patenting motive such as obtaining freedom to operate (Grindley and Teece, 1997;Hall and Ziedonis 2001; Ziedonis 2004;Blind, Edler,Frietcsh, and Schmoch 2006), signaling company's strength for potential infringement law suits particularly for larger companies that have patents very close to those of small companies, blocking other inventions and obtaining negotiation power in cross licensing agreements (Cohen et al, 2000;Cohen et al 2002; Davis, 2008). In general in such industries those patent filed with the intention of blocking others or providing their owner with freedom to manufacture as bargaining tools for cross licensing and licensing negotiations are categorized as play patents (Cohen at al, 2000;Cohen at al, 2002). While these patents might be used by their owner or through an agreement with others, they might also be left unused. For instance patents filed as bargaining tools might not be ultimately used due to bargaining or contracting failure. Such patents might also be utilized just to signal the company's power to other rivals or be filed just to serve as a counter-suit in litigation cases and therefore never be used in a product. A patent also may not be used by its owner as a result of other strategic motives such as avoiding the negative market effect of own innovation on existing products (Gilbert and Newbery,1984).

All these motivations might generate unused strategic patents which may have considerable value. Scotchmer (1991) argues that in industries which rely on cumulative technologies where inventions are built upon each other, the inducement of second round innovators which are building their innovation based on the first round inventions will be impacted by the threat of plausible patent infringements litigations. In industries relying on discrete technologies such as chemical and paramedical industries however, companies use strategic patents to prevent their rivals from imitating their core technology. Hence, they file numerous functionally similar patents around their core invention in order to create a protecting boundary to exclude rivals (Cohen, Nelson and Walsh, 2000). Such patents are in general very unlikely to be used internally or externally and are categorized as fence patents (Cohen at al, 2000;Cohen at al, 2002;Jung, 2009;Saunders 2002).

As a matter of fact while strategic patents might generate strategic rents to their owner who is paying a fee to hold her patent right, they may have negative social and economic consequences if by blocking alternative solutions that other inventions provide they hamper the possibility of better solutions. Patents are essentially meant as shielding tools for inventions, and for that reason they have the potential of generating monopoly power for their owner (Feldman,2008). As a result if patents are not used they support the monopoly without providing any social and economic benefits since the innovations based on those patents are not eventually exploited.

A patent which is not used with the intention of inhibiting entry of competitors into the market forces the new entrants to bear additional costs of inventing around, to pay royalties to the patent owner, or to bear perhaps severe ex-post fines (Harhoff, et al., 2007). According to Cohen (2004), the existence of strategic patents in the market for technology might negatively impact the development of innovation because the fundamental inventions might impede the exploitation of the follow-on innovations that might also restrict the speed and even the trail of the innovation. Galasso and Shankerman (2014) and Sampat and Williams (2014) however, provide evidence that the impact of patent rights on follow-on innovation is context specific and is not homogenous across technological fields. Adopting a new identification strategy in estimation of the causal impact of patent protection on follow on innovation Galasso and Shankerman (2014) use the patent invalidity decisions of the U.S. Court of Appeal for the Federal Circuit, founded in 1982 and has exclusive authority in appellate cases including patents. They argue that invalidation of patent rights has significant impact on downstream innovations only in computers and communications, electronics, and medical instruments (including biotechnology) fields and they find no evidence that invalidation of patent rights affect follow-on innovation in drugs, chemicals or mechanical technologies. Consistently in a recent contemporaneous study, Sampat and Williams (2014) employ administrative data on successful and unsuccessful patent applications submitted to the USPTO, to link the exact gene sequences claimed in each patent application. They employ two methods including simple comparison of follow-on innovation across genes and the “leniency” of the assigned patent examiner as an instrumental variable for whether the patent application was granted a patent both showing that gene patents have no impact on follow-on innovations.

The strategic use of patents also generates patent races in which marginal innovation is the basic incentive for patenting. Technology diffusion will be also delayed or even impeded by the presence of such unused patents. Therefore, for a more efficient utilization of resources and also from a policy viewpoint, studying strategic non-use of patents is of considerable significance.

To date, the literature has identified some factors explaining strategic patents. There exists few empirical studies that have distinguished between used and unused strategic patents (e.g. Torrisi et al., 2014) however no study has paid attention to unused play patents. Accordingly in this study we investigate the drivers of non-use of play patent. We focus on play patents since, first the innovation and the technology market mechanisms for play patents are very different from fence patents. Moreover, there exists higher variety of strategic intentions behind play patents as compared to fence patents which are not sufficiently explored by the literature. More importantly the importance of play patents is significantly highlighted in the literature as the drivers of patents thickets (Shapiro, 2001; Lemley and Shapiro, 2007; von Graevenitz et al., 2011) and patent hold ups (Lemley and Shapiro, 2005). We define unused play patents as those patents filed to block other's inventions or to be used as bargaining chips in licensing and cross-licensing deals (Cohen, et al., 2002), but are not used in an internal commercialization process by their owner or are not used externally through licensing, sale or creation of a spin off.

To test our hypotheses we use the data collected through PatVal II Survey on European inventors of 22,533 EPO patents resident in Europe, USA, Japan and Israel conducted between 2009 and 2011. The PatVal II Survey, ask among other things if a patent is used. It also asks the inventor's filing intention for each patent including strategic and non-strategic motives.

We contribute to the literature by examining the underlying technological mechanisms leading to patent nonuse. We provide novel evidence in exploring the antecedences of unused strategic patent which are intended to play. We show that the probability of non-use for play patents is higher for companies facing higher technological uncertainty. We also show that play patents held by companies involved in complex technological fields are more likely to be left unused.

The rest of this paper is organized as follows. In section 2 we present the literature review on strategic patent nonuse, discuss the theoretical background in more details and develop our hypotheses. In the third section the description of the data used in this study is presented. In section 4 the empirical methodology of the study along with our results is discussed. In section 5 we review the main findings and discuss the study's implications for the managers, policy makers and researchers.

## 2. Literature review

"Strategic use of the patent system arises whenever firms leverage complementarities between patents to attain a strategic advantage over technological rivals. This is anticompetitive if the main aim and effect of strategic use of the patent system is to decrease the efficiency of rival firms' production." (Harhoff, et al., 2007). Strategic patents are patents which are filed to serve a company's strategic purposes and as a result will not be used because they provide their owners with strategic rents (Giuri and Torrisi, 2011).

Different studies have shown that the strategic use of patents is one of the most important reasons behind forming large patent portfolios by companies in a number of industries (Cohen, Nelson and Walsh, 2000; Hall & Ziedonis, 2001; Bessen & Hunt, 2004). Blocking is one possible and common strategic use of patents by which the owner of an IPR intends to impede rivals from using their invention. According to the literature, strategic use of patents might be intended to *play* that is generally aimed for creating a credible insurance against probable infringement lawsuits threatening the company's inventions, blocking other's inventions and achieving negotiation power in cross-licensing agreements (Cohen et al, 2000;Cohen et al 2002). According to Allison, Lemley, and Walker (2009), strategic use of a patent in order to play consists of creating a patent portfolio with a large enough size including counter-suit patents which prevent rivals from suing the focal firm. This will provide the focal firm with freedom to operate and does not necessarily imply exclusion of the competitors from the market. In fact, the firm's player status will be guaranteed in an industry by means of preventing rivals from having control over all the essential rights in order to commercialize products through getting access to the rivals technologies via cross-licensing or at the very least possessing freedom to operate by achieving a credible counter-claim tool (Cohen et al 2002). Davis (2008) argues that play strategy consists of developing and patenting inventions by intellectual property vendors which are complementary to the buyer's invention and is used by firms which are interested in licensing or selling their IPRs to third parties. Therefore, while a company may intend to block other competitors' inventions by pursuing a play strategy, play strategy is not a pure blocking approach. Blind, et al., (2006), refer to this type of strategic patents as "defensive" patents.

Strategic use of patents might also be intended to fence with the aim of prevention of imitation by competitors (Cohen et al, 2000), particularly by firms encompassing huge patent portfolios which are more willing to exclude their competitors by making a shielding edge around their core technologies through patenting several substitute inventions (Cohen et al, 2002;Davis, 2008; Jung, 2009). Cohen et al, (2002) define fence patents as those blocking patent which are not intended to be used in cross-licensing and licensing ."Such fence building involves the patenting, though not licensing (nor necessarily even commercializing), of variants and other inventions that might substitute for the core innovation in order to preempt rivals from introducing competing innovations" Cohen et al (2000). For example, by patenting more than 200 substitutes for its core invention "Nylon", Du Pont tried to protect its core invention by employing fence strategy (Hounshell and Smith [1988]) which shows that although the company may use a focal patent internally but several fence patents around the core technology will remain unused with the aim of blocking competitors. "*Du Pont's patent policy stemmed from the nature of U.S. patent law, which allowed patentees to maintain patents even though such patents were not worked.... that is, they employed their researchers in finding small modifications or variations as well as alternatives to basic patents as a means of protecting a basic patent*"[2]. Saunders (2002) argues that a patent may not be commercialized by a firm in an industry in which "the norm is to patent en masse any and all innovations", where the intention of the patent holder is occupying the whole field by filing patents for all varieties or secondary applications of a core invention, although a huge number of patents filed might not be used or are of little use to the patent holder. In fact, fence patents are an example of "tragedy of the anti-commons" in the market for technology when valuable patents are under-utilized since the owners of the inventions block each other from exploiting their patents (Heller et al., 1998). Fencing is considered as a pure blocking action that excludes the rivals and gives the monopoly power to the blocker. Blind, et al., (2006), refer to strategically patented inventions used to fence as "offensive" patents.

[2] David A. Hounshell & John k. smith, JR., Science and corporate strategy: DU PONT R&D, 1902-1980 at 200 (1988).

Cohen et al. (2002) and Jung (2009) findings show that fence strategy is favored in discrete technologies such as chemical and pharmaceutical industry while play strategy is favored in complex technologies such as semiconductor industry. Although nonuse of patents with blocking intentions can encompass all fence patents, the use of patents to play is more than blocking since they are also used in licensing and cross licensing agreements (Cohen et al., 2002).

Consequently, the probability of nonuse for either of these two types of strategic patents seems to be different. In fact, by fencing a company may patent several substitute patents to keep competitors out and prevent their imitation when the single patents are not effectively preventing them from substitution or imitation (Cohen et al, 2000). In fact, fence patents might represent development upon the original product and the company may have no intention for commercializing them (Cohen et al., 2000). Hence, fence strategy in general creates a considerable number of unused patents. Accordingly, Jung (2009) refers to fence patents as "strategic nonuse patents". In fact play patents comparing to fence ones seem much more likely to be used since they can be used in cross-licensing and licensing agreements (Jung, 2009; Cohen et al, 2000) or even internally by their owner.

Consequently, fence and play patents can be further divided into used and unused patents. Unused ones comprise in general all fence patents. They may be also play patents which are intended to create a counter-suit threat against rival's infringement lawsuits that are also very unlikely to be used in an internal commercialization or an external use such as cross licensing or licensing deal unless the company settles litigation and enters a cross-licensing agreement to end the lawsuit. Finally, play patents which are filed to be utilized as bargaining tools may be also left unused in case of failure to conclude the agreement by parties. Used patents can be categorized as those play patents which are utilized externally in a cross-licensing or licensing agreement.

To date the literature has investigated some drivers for strategic patents. Firm-Specific characteristics such as firm size and possessing valuable downstream assets are discussed as some of these drivers. A number of studies have examined the link between firm size and strategic use of patents (Hall and Ziedonis 2001; Blind, Edler, Frietsch and Schmoch ,2006 ;Giuri, et al, 2007;Motohashi, 2008;Jung 2009; Jung and Walsh 2010) showing the importance and higher share of strategic patents for larger firms comparing to smaller ones. Possessing valuable downstream assets is another firm-specific characteristic argued by Jung (2009) to be positively associated to strategic defensive use of patents. Moreover, Jung and Walsh (2010) found technological maturity as a technology-specific characteristic is negatively associated to the rate of strategic patents on account of the lower uncertainty associated to general characteristics of mature technologies.

In this study we put one step further by investigating the antecedences of a particular type of unused strategic patents which is very common in cumulative industries. Accordingly we investigate the association between technology-specific factors such as technological uncertainty and technological complexity and unused play patents.

### 2.1 Hypotheses development

As it has been shown in the literature review, technology-specific characteristics such as technological uncertainty are discussed as a driver for sleeping patents (Weeds, 1999). Within the current body of the literature the impact of technology environment characteristics on the strategic nonuse of patents has been rarely studied. The only exceptions are the studies by Jung and Walsh (2010) and Torrisi et al., (2014). Torrisi et al, (2014) found that the presence of one competitor for the patent as a technology environment factor is positively associated with strategic use of patents. As another technology environment factor they also found that technological complexity is positively associated to strategic patenting.

Jung and Walsh (2010) investigated the effect of technological maturity and technological uncertainty on strategic nonuse of patents. They examined how evolutionary stages of technology development and firm capabilities influence the strategic non-use of patents by conducting empirical estimations, using data from Georgia Tech inventor survey. Their study examines the influence of technological maturity on strategic patenting and their results show that the probability of strategic non-use of a patented invention is lower in mature technologies due to the lower level of uncertainty as well as a favorable selection environment of technology associated to the general characteristics of mature technology. Their study also demonstrates that this effect is higher in complex technologies as compared to discrete technologies.

Although, Jung and Walsh (2010) explain the effect of technological maturity on strategic non-use of patents on account of the lower uncertainty associated to mature technologies, they have not examined the direct effect of technological uncertainty on strategic non-use of patents. Moreover, they have not distinguished between unused play patents vs. unused fence patents in their setting. Accordingly, following the same line of argument in explaining technology-specific characteristics we put one step further in our study by arguing that technological uncertainty may further explain unused play patents (as opposed to unused fence patents) by causing the cross-licensing and licensing agreements between companies fail since it increases the licensing transaction cost. Following Huchzermeier and Loch (2001) and Ziedonis (2007) we define technological uncertainty as the uncertainty associated to manufacturing and technical performance as well as the feasibility of the patented technology which influences its commercial potential eventually.

Within the market for IPR-based technologies, technological uncertainty may increase the transaction cost due to two main reasons; increase in information cost and increase in the bargaining and contracting cost. In the presence of technological uncertainty the licensees' concern about the value and the feasibility of commercialization of a new invention raises. Particularly, the licensee has lower technological information about the invention comparing to the licensor (information asymmetry) as a result of the learning effect (as in general the licensor has previous investment in related technologies) or the licensor's internal knowledge about the process of implementing the invention. The existence of information asymmetry raises the cost of information acquisition and as a result delays negotiations and elevates licensing transaction cost which may cause contracting failure.

*Bargaining and contacting cost* rise as a result of technological uncertainty. The literature on transaction cost economy, argues that the bargaining cost is higher in the presence of higher uncertainty (i.e. Williamson, 1981), which may cause impediments for parties in coming up with an agreement. According to Merges (1994) an important reason why an inventor and improver fail in concluding a bargain is the great uncertainty associated to technology's future development path and profitability. According to him, in presence of uncertainty both inventor and improver encounter a "classical situation" where they face occasional bargaining failures although both parties were able to achieve considerable gains in case of coming up with an agreement. He gives the example of bargaining breakdown involving patents caused by immense uncertainty in the early radio industry between Marconi Wireless Telegraph Company's patented diode and De Forest's patented triode which is considered in the literature as a classic example for blocking patents(Yosick;2001). "*The Marconi Wireless Telegraph Company held the Fleming patent for the diode used in the radio industry, while De Forest held patents for the triode, which was an improvement of the Fleming pioneering patent. As holder of the dominant patent, Marconi was able to block use of the improvements, and the parties were unable to come to a licensing agreement. The outbreak of World War I forced a resolution, but the dispute delayed the development of the radio by several years*" (Yosick;2001).

According to Arrow (1969) also, contracts can be rendered incomplete finally, since the nature of the knowledge is tacit and there is an inherent risk associated to it, implying that the uncertainty about the future and value of a technology impedes parties from concluding the negotiations (Arrow, 1969; Oxley, 1997).

Therefore, although use of a patent as a bargaining chip in licensing and cross licensing agreements could be a result of uncertainty as cross licensing will decrease the risks and costs associated to possible future infringement lawsuits, but uncertainty can also prevent a licensing or cross licensing agreement from being concluded through rising the transaction cost and therefore can create unused patents which can be categorized as unused play patents as argued. In fact, in spite of the fact that technological uncertainty provides the incentive to play in the market for technology by raising the importance of achieving bargaining tools, it impedes the utilization of these tools because parties are hardly able to conclude a deal. Even if some contracts are rendered, the uncertainty leads to continual updating of contracts and incurring the considerable costs associated to renegotiations which in many cases are not reasonable and therefore renegotiations will not be continued (eventually causes contracting failure). Williamson (1991) argues that in the presence of uncertainty contract are very repeatedly misaligned throughout the extensive period of costly renegotiations among parties. Therefore, uncertainty about the technology may encourage firms to adapt a play strategy to equip themselves with negotiation tools, but at the same time may cause negotiation (and renegotiation) efforts to fail by increasing transaction cost and therefore create unused play patents. Therefore we forward our first hypothesis as:

***H1)*** *Play patents held by companies dealing with technological uncertainty are more likely to be left unused.*

There exist a positive link between technological complexity as another technology environment factor and strategic patenting (Torrisi et al, 2014). However, technological complexity may also explain unused play patents as a type of unused strategic patents. We focus our attention on technological complexity in this study particularly due to the importance of this factor in strategic patenting literature. According to Cohen et al., (2000), complex technologies are distinguished from discrete technologies as “a new, commercializable product or process is comprised of numerous separately patentable elements versus relatively few”. Therefore, in contrast with discrete technologies, complex technologies which are generally the underlying technology in cumulative industries are characterized by a high level of interdependency between patents and a considerable number of overlapping IPRs. Such interdependency requires firms’ access to large number of patents as a result of their lack of control over the entire technologies and essential complementary components needed for developing their products and therefore companies in such industries tend to massively accumulate patents. In fact, in such industries, firms are mostly led through patent thickets (Shapiro, 2001). As a result in complex technological fields many competitors are holding patents in order to build up large patent portfolios as a powerful means of bargaining and negotiation as well as a way to decrease the risk of being held up by competitors and prevent patent infringement lawsuits (Heller and Eisenberg 1998;Cohen et al ,2000; Shapiro, 2001; Hall and Ziedonis, 2001; Cohen et al ,2002) which leads to creation of play patents.

Technological complexity can also increase the transaction cost in the market for technology and therefore firms involved in industries with complex technologies, generally rely on patenting as a strategic tool for negotiations and preventing infringement lawsuits. In fact, in cumulative industries and complex products innovator firms are dealing with excessive transaction costs as a result of the necessity for bargaining and negotiating with many patent right holders (Heller and Eisenberg, 1998). Consequently, technology transfer by means of licensing or sale is not well supported by the market for technology. Therefore, the main motivation for firms in using licensing in such industries is to play by achieving freedom-to-manufacture, to gain bargaining and negotiation control in litigations or to prevent patent infringement lawsuits (Gallini, 1984;

Gallini and Wright. 1990). Giuri and Torrisi (2010) also argue that technological complexity as technology characteristics and cumulativeness and overlapping claims as patent characteristics have a significant role in cross-licensing implying that cross-licensing can be helpful for patent holders in order to decrease transaction costs. Such importance will be more critical when it comes to complex technologies as in case of complex technologies getting blocked or blocking is probable because of the high number of interconnected patents required for a complex product or process which brings about a high negotiations cost for the patent owners. Hence, cross licensing is more common in complex technologies as compared to discrete ones.

All in all, it can be argued that holding a patent in order to play is of high importance to the firms involved in complex technological fields. Cohen et al., (2000) show that in complex industries such as electronics or semiconductors filing patents is often intended to play. This is particularly common for high capital-intensive firms which are more vulnerable to patent infringement lawsuits (Hall and Ziedonis, 2001; Ziedonis, 2004). However although technological complexity might create a considerable share of play patents it might also hamper the use of them. First of all, although cross licensing is more common in industries with complex underlying technologies, the excessive transaction cost resulted by technological complexity in such industries may prevent cross licensing agreements from ending and as a result may cause unused play patents. Secondly, a share of the play patents which are resulted by technological complexity and are intended to be utilized as countersuits in case of future infringement lawsuits are very unlikely to be used by their owners in an internal commercialization process or externally as argued. Hence we posit that:

***H2)*** *Play patents held by companies involved in complex technological fields (vs. discrete technological fields) are more likely to be left unused.*

## 3. Data and descriptive statistics

### 3.1 *Data*

With the aim of testing the hypotheses in our study we employ primary data from PatVal II database which is a cross-country database developed within InnoS&T project sponsored by the European Commission. The survey started in 2009 in Europe and Israel and ended in US and Japan in 2011. The survey is intended for studying the determinants of patent licensing, patent sale and new venture creation by firms, universities and PROs. It inspects several key dimensions of the inventive process, involving the origin of new ideas, the organization and sources of inventive activities, the reasons for patenting and the use of patents, by surveying inventors of 22,533 EPO patents with propriety dates between 2003 and 2005 resident in Europe (Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Sweden, Slovenia), USA, Japan and Israel, through employing a harmonized questionnaire across all the surveyed regions. In comparison to earlier innovation and patent surveys, PatVal II provides a broad international coverage of the antecedents and uses of patented inventions (Torrisi et al, 2014).

There are a number of indicators obtained through PatVal II database. The PatVal II Survey, asks among other things if a patent is used. It also asks the inventor's filing intention for each patent including strategic motives such cross-licensing, prevention of imitation, blocking patents, prevention of infringements suits, reputation and pure defense to ensure that the use of own technology is not blocked by others and, non-strategic motives including commercial exploitation, licensing and intention to use in technical standards. Our unit of analysis in this study is EP patent. Table 1 shows the share of nonuse for play and fence patents in our sample.

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Insert Table 1 about here
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## 4. Measurements, data analysis and regression results

### 4.1 Measurement

***Dependent variable***

**Unused play Patents**

For operatiolizing this variable we use a dummy equal to 1 if the patent has not been used by any of the inventors and the important motivation (>3) for patenting is reported not for *prevention of imitation* but for *blocking patents* and *cross licensing* or *licensing* (Cohen et a., 2001). PatVal II askes among other things if the applicant(s) or affiliated parties ever used the patented invention commercially or if the ownership right to the patent was sold or licensed to another party not related to the original owner(s) or applicant(s), or if this patent been used by any of the inventors or applicants to found a new company.It also askes the inventors motivation when filing the invention. Through this measure, we make sure that our operationalization of unused play patent is exclusive from fence patents which are strategically used to prevent competitors from imitating the firm's core technology.

***Independent variables***

**Technological Uncertainty (TM):** For the sake of operationalizing technological uncertainty (TU) we use the measure utilized by Djokovic and Souitaris(2007), originally devised by Lowe (2003) which is based on the average age of the cited patents (PCj). Before a patent gets issued, the prior inventions that must be cited will be determined by the patent officers through researching previous patents. Each cited patent by the patent refers to a particular issuance date when it was issued. The idea is that the technology field will get more certain and mature, with higher average age of the citation**.** Following Djokovic and Souitaris(2007), technological uncertainty is measured based on the average age of the patents cited (PCj) where j is the number of the cited patents. The validity of this measure is due to the fact that it evaluates the level of uncertainty at the time the patent was issued and as a result is not a retrospective measure for technological uncertainty (Djokovic and Souitaris, 2007). Lowe (2003) gives an example of average age of cited patent as if a patent is issued in 1990 and is citing two patents, one issued in 1980 and the other issued in 1970, then the average age of cited patents is calculated as (10+20)/2=15. As PCj ,technological uncertainty and j can take the value of zero Djokovic and Souitaris(2007) measure technological uncertainty as :

$$TU = \frac{1}{1 + \sum_j PC_j}$$

Although technological uncertainty can be measured through asking experts such as inventors, technology transfer officers and patent lawyers about each single patent at the time of publication as suggested by Walker and Weber (1984) for measuring technological uncertainty of products for a limited number of established companies, Djokovic and Souitaris (2007) purposed measure overcomes two important limitations of the this approach with respect to our study. First, considering the number of patents in our sample the Walker and Weber (1984) approach limits our sample size and is costly to be accomplished for each individual patent(Markman et al., 2004). Second, their approach is impracticable for the purpose of this study as the patents in our sample are already published for couple of yours and therefore their measure will provide us with a retrospective measure for technological uncertainty.

**Technological Complexity (TC):**

For operationalizing technological complexity we use two alternative measures. First, following Giuri and Torrisi (2010), we classify the patent rather than the firm's sector in accordance with the level of complexity of its underlying technology since as they argue even though Cohen et al., (2000) distinguish high complexity industries from low complexity ones, their classification is derived from technological dimensions. Consistent with their approach, we use a dummy in order to operationalize the variable technological complexity. This dummy takes the value 1 when the patent belongs to one of the following classes: Electrical devices, engineering, energy, Audio-visual technology, Telecommunications, Information technology, Semiconductors, Optics, Analysis, measurement, control technology, Medical technology, Machine tools, Engines, pumps, turbines, Transport, Nuclear engineering, Space technology weapons.

As the second measure for technological complexity we use average for triples employed by Torrisi et al., (2014). Triples are introduced by von Graevenitz et al. (2013) as the size of the complexity and are defined as citations link between three companies within each OST technology area. Von Graevenitz et al. (2013) define triple as the group of three companies in which each company has critical prior art limiting claims on recent patent applications of each of the other two firms, from the backward XY citation point of view . Therefore, they measure triples as the count for frequency with which three companies holding EP patents claimed in the other two firms' patents as X or Y references between 1988 and 2002. Following Torrisi et al., (2014), we measure Triples(mean) as the average for triples over this period. The higher the Tripe(mean) the higher the complexity a firm faces in the market for technology.

**Control Variables:**

We control for firm, patent, technology and country level factors in our estimations. We control for the size of the firm as firm size is considered as a general factor explaining patent nonuse by previous literature (Giuri and Torrisi,2011; Hall and Ziedonis ,2001; Blind et al., 2006; Giuri, et al., 2007; Motohashi ,2008; Jung and Walsh, 2010). We control for firm size by using 7 dummy variables. Through these dummies we distinguish the size by number of employees from the small firms employing less than 50 workers (baseline category accounting for 10.03% of our observations) to very large organizations (more than 5000 employees representing 56.73 % of observations). We also control for the age of the firm. We employ 4 dummy variables distinguishing young firms less than 5 years-old from more mature firms. We further control for the presence of the competitors at the time of the invention. The presence of competitors at the time of invention might increase the likelihood of strategic motives while filing the patent application in order to achieve freedom to operate, to use the patent as a negotiation chip, to prevent future lawsuits or to protect a product or process which might lead to strategic nonuse of patents if the patent is merely field to be used as a countersuit or the bargaining negotiation fails. We use 3 dummies distinguishing the presence of no competitor from the presence of one competitor or several competitors.

We also control for patent-level characteristics. First we control for the number of inventors for each patent as a measure for the efforts that have been devoted to develop an invention. The higher the number of inventors for each patent the less might be the probability that it will be left unused since more efforts has been dedicated to accomplish it. Furthermore, to control for the scope of the patent we use number of claims included in the patent document. We also control for the significance of prior patent documents through controlling for the number of backward citations. Moreover, we control for the number of overlapping claims as a measure for legal validity of the patent. In European patent system citations classified as “X” or “Y” references can be labeled as blocking citation (Czarnitzki, Hussinger and Leten, 2011). X/Y references can partly hamper the patentability of the competitors’ inventions and their R&D activities (Grimpe and Hussinger, 2008a,b; Guellec et al., 2009). In fact the owner of the cited patent will be benefited because other competitors are deprived of getting patents on similar inventions (Guellec et al., 2008) or the scope of their patents will be narrowed. Therefore, X and Y references might affect the likelihood of litigation as they are indicators for lack of novelty or inventive step and as a result might cause strategic patent non-use. At the patent level, we also control for the priority year of patents (2003-2005). We also control for the country of the applicant as a dummy variable. 5 dummies indicating the region of the inventor of the patent including Europe, US, JP, Israel and the rest of the world. At *technology level we control for technological class*es and at the industry level we also control for SIC codes.

Table 2 shows the list of variables used in our analyses along with their descriptions and sources.

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Insert Table 2 about here
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### 4.2 Empirical Framework

The descriptive statistics for our variables and their correlation matrix are presented in Table 2 and Table 3.

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Insert Table 3 and Table 4 about here
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### 4.3 Regression results and discussion

We checked whether multicollinearity existed among our explanatory variables before carrying the econometrics analysis. In fact, multicollinearity is considered as one of the most typical econometrics issues with cross-sectional regressions. For our model, Pearson correlation coefficients were all < 0.5 except for few values for some of our control variables firm age, firm size and the country of the applicant in the correlation matrix of the covariates. We further investigated the issue by computing variance inflation factor. We found that VIF is less than 2 for all our variables. Moreover, the average variance inflation factor for our model is 1.27.

Since our dependent variable *unused play patent* is a dichotomous variable we employed probit estimation to carry our analysis (Greene, 2000). The results of the probit estimation are shown in Table 5.

In the first column of the table we show the average marginal effects for the direct effect model including our dependent variable and both of our explanatory variables. Then we run the control model including patent, firm, technology and country level variables. Column 2 shows the results of the probit estimation for our control model. Column 3 to 4 show the average marginal effects after progressively adding our main regressors including technological uncertainty and technological complexity. Since, the progressive inclusion of the variables does not really affect the significance and magnitude of each variable we interpreted the results of the last model (column 4).

Hypothesis 1 is related to the association between technological uncertainty and nonuse of play patent. As it is shown in column 4 the coefficient for technological uncertainty is positive and significant.  Our results show that play patents held by firms involved in complex technological fields (as opposed to discrete technological fields) are more likely to be left unused . This is in line with our expectation that technological uncertainty might create bargaining failure for the parties holding play patents through raising the transaction cost in the technology market and therefore increase the likelihood of nonuse of these patents. The magnitude of the link between technological uncertainty and the nonuse of play patents is considerable although we have controlled for various patent, firm and technology observable factors.  As shown in Table 5 technological uncertainty increases the probability of nonuse of play patents by 20.6%.

Hypothesis 2 is regarding the link between the technological complexity and unused play patent. Technological complexity is positive and significant increasing the likelihood of non-use of play patents by 2 %.  This result is also in line with our expectation. Similar to Technological uncertainty , technological complexity might also increase the transaction cost in the market for technology and impede parties owning play patents intended to be employed as bargaining chips to come into a final agreement to use their technology. Technological complexity might also make the use of an invention difficult which might hinder the use of play patents in possible internal or external commercialization processes.

In order to further explore the link between technological complexity and unused play patents we employ the average number of triples used by Torrisi et al., (2014) to measure technological complexity that is computed by von Graeventiz et al. (2013) as a measure for the density of patent thickets. Model 5 reports the result of this estimation showing a positive and significant marginal effect of the average of triples on unused play patents. It's worth mentioning that von Graeventiz et al (2013) have calculated the number of triples at a relatively high aggregation level. As a result the marginal effect of the triples might be attenuated due to the heterogeneity within each of the thirty technological areas (Torrisi, et al, 2014)

We control for firm, patent, technology and country level factors.  As expected the marginal effect of large (1000-4999 employees) and very large (over 5000 employees) firms are positive and significant on unused play patents as compared to baseline category (less than 50 employees). This might imply that the complexity and size of the patent portfolios of large and very large licensors increases the probability of holding unused patents by these companies. Morover, the magnitude for legal validity (overlapping claims) while zero is not significant.

Priority year while positive is not significant too. Moreover, the magnitude for patent scope (number of claims) and number of backward citations is zero. While negative we also don't find number of inverntors and the dummies for the country (region) significant.

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Insert Table 5 about here

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## 5. Implications and conclusion

Using a novel database of inventors, this study investigates the drivers of unused strategic patents with particular focus on unused play patents. We employ data from the PatValII survey containing data for a sample of 23,044 inventor-invention pairs in Europe, Japan, Israel and the U.S. The survey was conducted in 2009-2011 with the aim of providing novel evidence about the characteristics of the inventive process leading to patent applications filed at the EPO.

Our findings can be summarized as follows. First, a considerable share of the patents in our sample is left unused (35%) out of which 19% are unused play patents and 10.90 % are unused fence patents. Moreover, our probit estimation showed that play patents held by companies dealing with higher technological uncertainty are more likely to be left unused. This is consistent with other studies by (Jung 2009, Jung and Walsh 2011) that find technological maturity is negatively associated to the rate of strategic use of patents on account of higher uncertainty. Our finding is also in consistence with the evolutionary arguments on technology development by the literature (Dosi, 1982; Henderson and Clark, 1990; Nelson and Winter, 1982).

We also find evidence for the argument that play patents held by companies involved in complex technological fields (vs. discrete technological fields) are more likely to be left unused.

Therefore, while studies argue that the rate of play patents is higher in complex technological fields (e.g. Cohen et al., 2002) as the propensity to file a patent as a mean to gain freedom to operate and achieve negotiation power in cross licensing and litigations is higher in these fields, we further find that technological complexity itself is a driver for the nonuse of play patents.

The literature on transaction cost economy argues that companies' ex-post opportunistic behaviors can be a result of complexity and uncertainty. Contracts or assets encompassing more complex or uncertain components might provide a better opportunity for the parties to act based on their individual benefits (Klein, Crawford, and Alchian, 1978; Williamson, 1991). As a result the transaction would be suppressed and higher controls would be imposed since there are several risks and hazards associated to the contracts suffering from high complexity and uncertainty. Therefore, in line with this stream of the literature we argue that although technological complexity and technological uncertainty might increase the propensity to file play patents, they also impede the use of play patents most importantly by increasing the transaction cost in the market for technology.

Our results also show that large and very large companies are more likely to hold unused play patents. This result is in consistence with other studies (Giuri and Torrisi,2011; Hall and Ziedonis ,2001; Blind et al., 2006; Giuri, et al., 2007; Motohashi ,2008; Jung and Walsh, 2010) which show that in general the size of the firm is negatively related to the use of patents. This might reflect the fact that the complexity and size of the patent portfolios of large licensors makes it complicated for them to evaluate the value and the potential use and application of their patents.

**Study limitations and future research**

We contribute to the current body of the literature on strategic patenting through investigating the drivers of unused play patents. Previous studies have investigated some drivers associated to strategic patents, however our study puts one step further to examine the drivers of unused strategic patent with particular focus on unused play patents. Our results provide theoretical and empirical ground for future studies concerning strategic patenting and use of patents.

The characteristics of technology and markets within industries relying on complex technologies are very different from those in discrete technological fields in terms of invention development process, IPR structure and positioning and mechanisms. Considering the wider variety of strategic intentions behind filing play patents and due to the significance of these patents as the drivers of hold ups and patent thickets, we focused our attention on these types of strategic patents with the purpose of exploring their drivers more in depth. Future, research could further explore the drivers of unused fence patents and provide a comparative bench mark for the characteristics and determinants of both types of strategic patents. Furthermore, our data is cross-sectional. Future, research could employ longitudinal data in order to explore more dynamic market and technology level factors which can explain strategic non-use of patents.

In line with other studies' arguments on the welfare effects of strategic patenting, our research suggests that although companies might apply for strategic patents to gain strategic rents, such strategic behaviors might be detrimental to social welfare as they cause nonuse of resources. However, to date it has not been clear to what extent strategic benefits of a company might negatively affect the society and what could be the most feasible and efficient policies to deal with that. Future research could shed light on this unexplored ambiguity.

Our study investigated the antecedences of unused strategic patent. Future studies could be done in order to explore those patent, firm and market level mechanisms which might favor the use of these patents. It would be also nice to explore more in depth different strategic motives leading to strategic nonuse of patents by employing a more qualitative approach.

**Policy implications**

This study contributes to the literature on strategic management of intellectual property rights by identifying new determinates of patent nonuse through examining factors explaining unused strategic patents. The study provides new evidence in order to fill the gap in empirical analysis of unused play patents by employing an original set of data adding to the discussion on strategic patenting and patent non-use.

There exists a growing concern among management scholars and policy makers regarding patent non-use. Our study along with other studies within the literature suggest that in designing policies to tackle this issue governments and policy makers should be aware of the differences between various types of unused patents and their antecedences since the role of patents for companies is heterogeneous across the technological contexts. In other words the issue of nonuse should not be tackled by employing a general policy design and should be targeted with respect to the industry and technology specifications differences.

The negative social outcome of the strategic non use of patents could be tackled by employing proper policies. One suggested approach is compulsory licensing that imposes the holder of a strategic patent with high value to the society to provide licenses to others (Moser and Voena, 2012; Yosick, 2001). However, since this approach is not favored in many countries the policy makers should take into account alternative approaches such as encouraging firms to contribute to patent aggregation mechanisms such as modern patent pools that are particularly designed to reduce strategic and anti-competitive behaviour and facilitate the technology commercialization (Lampe and Moser, 2014).

As a matter of fact, IPR and competition policies can affect the contracting environment in the market for technology and therefore impact different strategic patenting intentions. However, overcoming the issue of nonuse and its negative social consequences would be a challenging task particularly with unused play patents. On the one hand, aggressive protection policies might be employed in markets with highly fragmented IPRs to avoid competitors using each other's technology. On the other hand, this might grow the strategic and opportunistic behaviors of the companies that often take advantage of their patent right monopoly power and therefore increase the share of strategic patent which will be filed with pure strategic intentions. Nonetheless, the degree of the enforcement of IPR law might vary across countries and regions. Some regional policies might be more towards less aggressive enforcement of laws to decrease strategic motives among competitors in order to reduce the rate of strategic patenting. However, this may also negatively affect the protection of the inventions which are developed without any strategic intentions. This implies that even by taking in to account the context specificity considerations while designing and implementing policies, the importance of the differences across the role of patents for different firms should not be overlooked which is of course a challenging consideration to undertake.

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**Table 1- Share of unused strategic patents in our sample *(N=8245)***

| Variable | Share in our sample % |
|---|---|
| **Unused patents** | 35.16 |
| **Unused play patents** | 19.2 |
| **Unused fence patents** | 10.90 |

**Table 2- Variables used in this study**

| Variable | Description | Source |
|---|---|---|
| **Play(Unused)** | *Dummy*- dummy equal to 1 if the patent has not been used by any of the inventors and the important motivation (>3) for patenting is reported not for *prevention of imitation* but for *blocking patents* and *cross licensing* or *licensing*. | PatVal II |
| **Technological Uncertainty** | Technological uncertainty is measured based on the average age of the patents cited (PCj) where j is the number of the cited patents : $TU = \frac{1}{1+\sum_j PC_j}$ (Djokovic and Souitaris, 2007; Lowe , 2003) | UC Berkeley Fung database, EPO Patstat |
| **Technological Complexity** | *Dummy*- dummy equal to 1 when the patent belongs to one of the following classes: Electrical devices, engineering, energy, Audio-visual technology, Telecommunications, Information technology, Semiconductors, Optics, Analysis, measurement, control technology, Medical technology, Machine tools, Engines, pumps, turbines, Transport, Nuclear engineering, Space technology weapons. (Giuri and Torrisi, 2010) | WIPO, EPO Patstat |
| **Triples** | Average number of triples (cross X or Y references among three firms) calculated by von Graevenitz et al (2013) by 30 OST technology area | von Graevenitz et al (2013) |
| **Priority year** | *Dummy*-The year in which the invention was filed to EPO | EPO Patstat |
| **No. of Backward Citations** | Total number of backward citations the patent has received | UC Berkeley Fung database, EPO Patstat |
| **Patent Scope (No. of claims)** | Number of claims included in the patent document | UC Berkeley Fung database, EPO Patstat |
| **No. of inventors** | Number of inventors for each patent | EPO Patstat |
| **XY Patent Reference** | Number of overlapping claims with earlier patents (X or Y references assigned by patent examiners) | EPO Patstat |
| **Missing XY Reference** | *Dummy*- equal to 1 if XY Reference is missing | EPO Patstat |
| **Firm size** | *Dummy*-7 dummy variables to distinguish the size by number of employees from very small firms (1-49 employees) to very large organizations (more than 5000 employees). | PatVal II , Amadeus, Lexis Nexis, Osiris |
| **Firm age** | *Dummy*—4 dummies distinguishing the age of the licensor from young to more mature | PatVal II , Amadeus, Lexis Nexis, Osiris |
| **Missing firm age** | *Dummy*- equal to 1 if firm age is missing | PatVal II |
| **Region** | *Dummy*—5 dummies indicating the region of the inventor of the patent including Europe, US, JP, Israeli and the rest of the world. | EPO Patstat |
| **Technological class** | Technological classes based on EPO classification | EPO Patstat |
| **Industry** | 3 digit SIC codes | PatVal II |

## Table 3- Descriptive statistics *(N=8245)*

| Variable | Mean | S.D. | Min | Max |
|---|---|---|---|---|
| **Play (Unused)** | 0.198 | 0.4 | 0 | 1 |
| **Technological Uncertainty** | 0.107 | 0.059 | 0.028 | 1 |
| **Technological Complexity** | 0.613 | 0.487 | 0 | 1 |
| **Triples** | 26.96 | 33.55 | 0 | 117.70 |
| **Propriety year- 2003** | 0.374 | 0.484 | 0 | 1 |
| **Propriety year- 2004** | 0.38 | 0.486 | 0 | 1 |
| **Propriety year- 2005** | 0.245 | 0.43 | 0 | 1 |
| **No. of inventors** | 2.676 | 1.833 | 1 | 19 |
| **No. of claims** | 17.152 | 13.01 | 1 | 228 |
| **No. of backward citations** | 14.517 | 32.775 | 1 | 830 |
| **XY References** | 4.431 | 2.892 | 0 | 43 |
| **D-Miss-XY Refs** | 0.069 | 0.253 | 0 | 1 |
| **Firm age < 2 Yrs** | 0.033 | 0.178 | 0 | 1 |
| **Firm age 2-4 Yrs** | 0.065 | 0.246 | 0 | 1 |
| **Firm age 5-10 Yrs** | 0.081 | 0.272 | 0 | 1 |
| **Firm age 11- 20 Yrs** | 0.103 | 0.304 | 0 | 1 |
| **Firm age > 20 Yrs** | 0.719 | 0.45 | 0 | 1 |
| **D-Miss- Firm age** | 0.045 | 0.207 | 0 | 1 |
| **Firm size 1-49 epml** | 0.1 | 0.3 | 0 | 1 |
| **Firm size 50-99 empl** | 0.029 | 0.169 | 0 | 1 |
| **Firm size 100-249 empl** | 0.051 | 0.22 | 0 | 1 |
| **Firm size 250-499 empl** | 0.052 | 0.221 | 0 | 1 |
| **Firm size 500-999 empl** | 0.051 | 0.219 | 0 | 1 |
| **Firm size 1000-4999 empl** | 0.15 | 0.357 | 0 | 1 |
| **Firm size 5000-9999 empl** | 0.567 | 0.495 | 0 | 1 |
| **JP** | 0.007 | 0.086 | 0 | 1 |
| **IL** | 0.277 | 0.447 | 0 | 1 |
| **US** | 0.006 | 0.079 | 0 | 1 |
| **EP** | 0.306 | 0.461 | 0 | 1 |
| **Rest of the world** | 0.403 | 0.491 | 0 | 1 |

## Table 4 Correlation Matrix *(N=8245)*

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1. Play (Unused)** | 1 | | | | | | | | | | | | |
| **2. Technological Uncertainty** | 0.05*** | 1 | | | | | | | | | | | |
| **3. Technological Complexity** | 0.04*** | 0.14*** | 1 | | | | | | | | | | |
| **4. Propriety year- 2003** | -0.01 | -0.03* | 0.03* | 1 | | | | | | | | | |
| **5. Propriety year- 2004** | 0 | 0 | -0.02† | -.61*** | 1 | | | | | | | | |
| **6. Propriety year- 2005** | 0.01 | 0.03* | -0.01 | -.44*** | -.45*** | 1 | | | | | | | |
| **7. No. of inventors** | 0 | -.09*** | -0.01 | 0 | 0.01 | -0.01 | 1 | | | | | | |
| **8. No. of claims** | -0.02 | 0.05*** | -0.01 | 0.02† | 0.02 | -0.04*** | 0.08*** | 1 | | | | | |
| **9. No. of backward citations** | -.04*** | -.04*** | -.1*** | -0.01 | 0.01 | 0 | 0.07*** | 0.18*** | 1 | | | | |
| **10. XY References** | -0.02 | -.06*** | -.09*** | .07*** | 0.01 | -0.09*** | 0.03*** | 0.02 | 0.06*** | 1 | | | |
| **11. Firm age < 2 Yrs** | -0.01 | 0.02† | 0 | -.02† | 0 | .02† | -.01 | 0.03*** | 0.03*** | -.01 | 1 | | |
| **12. Firm age 2-4 Yrs** | -0.01 | 0.03* | 0.01 | 0.02 | 0 | -0.01 | 0.01 | 0.05*** | 0.06*** | -.01 | -.05*** | 1 | |
| **13. Firm age 5-10 Yrs** | -0.02 | 0.01 | 0 | -0.01 | -0.01 | 0.02 | 0 | 0.04*** | 0.02 | 0 | -.05*** | -.08*** | 1 |
| **14. Firm age 11- 20 Yrs** | -0.01 | 0.03*** | 0.01 | -0.02 | 0.01 | 0.01 | -.02 | 0.05*** | 0.01 | 0 | -.06*** | -.09*** | -.1*** |
| **15. Firm age > 20 Yrs** | 0.06*** | -.05*** | -0.01 | 0.02 | 0 | -0.02 | 0.01 | -0.1*** | -.06*** | 0.01 | -.29*** | -.42*** | -.47*** |
| **16. Firm size 1-49 epml** | -.05*** | -0.01 | -0.02† | 0.01 | 0 | 0 | -.09*** | 0.08*** | 0.08*** | 0.01 | 0.31*** | 0.29*** | .16*** |
| **17. Firm size 50-99 empl** | -0.03** | -0.02 | -0.01 | 0.02 | -0.02 | 0 | -.01 | .03* | .02* | .02* | 0.01 | 0.05*** | .11*** |
| **18. Firm size 100-249 empl** | -.04*** | -.06*** | -0.03* | 0.01 | -0.01 | -0.01 | 0 | 0.03*** | .02* | 0 | -.02* | 0.04*** | .04*** |
| **19. Firm size 250-499 empl** | -.06*** | -0.01 | -0.03* | 0 | 0.01 | -0.01 | -0.01 | 0 | -0.01 | 0.02 | -0.01 | -.02 | 0 |
| **20. Firm size 500-999 empl** | -0.02** | -0.03* | -0.02† | 0.01 | 0.01 | -0.01 | -.02† | 0 | 0 | -0.01 | -.03*** | -.03* | -.01 |
| **21. Firm size 1000-4999 empl** | -0.02† | -0.03* | -0.02* | 0 | 0 | 0 | -0.02 | -.05*** | -.03* | 0.01 | -.05*** | -.06*** | -.06*** |
| **22. Firm size 5000-9999 empl** | 0.11*** | 0.07*** | .06*** | -0.01 | 0 | 0.01 | 0.08*** | -.03*** | -.04*** | -.03*** | -.12*** | -.15*** | -.1*** |
| **23. JP** | 0 | 0.03* | 0.01 | -0.01 | 0.01 | 0 | -.01 | 0.03 | 0.02 | -0.01 | -0.01 | 0 | 0.04 |
| **24. IL** | 0.04*** | 0.05*** | 0.09*** | 0 | 0 | 0 | 0.06*** | -.24*** | -.14*** | 0.05*** | -.06*** | -.08*** | -.09*** |
| **25. US** | -0.01 | 0.02 | 0.01 | 0 | 0.02 | -0.02 | 0.02 | 0.03* | 0 | -0.01 | 0.03* | .08*** | 0.02 |
| **26. EP** | -.04*** | 0 | 0 | -0.01 | 0.01 | 0 | 0.04*** | 0.28*** | 0.24*** | -0.02 | 0.07*** | .06*** | 0.05*** |
| **27. The rest of the world** | 0 | -.05*** | -.08*** | 0.01 | -0.01 | 0.01 | -.09*** | -.05*** | -.1*** | -0.03* | -0.02 | 0.01 | 0.02 |
| **28. Triples (mean)** | 0.07*** | 0.19*** | 0.5*** | -0.01 | 0.01 | 0.01 | -.05*** | 0.09*** | -.07*** | -.08*** | 0.03*** | 0.01 | 0.01 |

*** p < 0.001, p** < 0.01, * p < 0.05, † p < 0. 1

## Table 4 Correlation Matrix (continued)

| Variable | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15. Firm age 11- 20 Yrs | -0.01 | | | | | | | | | | | | | | |
| 16. Firm age > 20 Yrs | .06*** | 1 | | | | | | | | | | | | | |
| 17. Firm size 1-49 epml | -.05*** | 0 | 1 | | | | | | | | | | | | |
| 18. Firm size 50-99 empl | -0.03** | -.41*** | -.05*** | 1 | | | | | | | | | | | |
| 19. Firm size 100-249 empl | -.04*** | -.12*** | 0 | -.06*** | 1 | | | | | | | | | | |
| 20. Firm size 250-499 empl | -.06*** | -.07*** | -.01 | -.08*** | -.04*** | 1 | | | | | | | | | |
| 21. Firm size 500-999 empl | -0.02** | -.02 | .13*** | -.08*** | -.04*** | -.05*** | 1 | | | | | | | | |
| 22. Firm size 1000-4999 empl | -0.02† | .01 | .06*** | -.08*** | -.04*** | -.05*** | -.05*** | 1 | | | | | | | |
| 23. Firm size 5000-9999 empl | .11*** | .1*** | 0 | -.14*** | -.07*** | -.1*** | -.1*** | -.1*** | 1 | | | | | | |
| 24. JP | 0 | -.03* | .02 | 0 | 0.03* | 0 | .01 | -.01 | -.01 | 1 | | | | | |
| 25. IL | .04*** | .18*** | .04*** | -.16*** | -.07*** | -.08*** | -0.01 | -.02† | .14*** | -.05*** | 1 | | | | |
| 26. US | -0.01 | -.08*** | 0 | .07*** | .06*** | .03* | 0 | 0 | .01 | -.01 | -.05*** | 1 | | | |
| 27. EP | -.04*** | -.12*** | -.01 | .11*** | .04*** | .05*** | -.01 | -.01 | -.08*** | -.06*** | -.41*** | -.5*** | 1 | | |
| 28. The rest of the world | 0 | -.03* | -.03* | .03*** | 0.01 | .02* | .02 | .03*** | -.05*** | -.07*** | -.51*** | -.7*** | -.55*** | 1 | |
| 29. Triples (mean) | .07*** | -.07*** | -.04*** | -.02** | -.07*** | -.03*** | -.03*** | -.03*** | .12*** | .01 | .06*** | .02 | .02† | -.08*** | 1 |

*** p < 0.001, p** < 0.01, * p < 0.05, † p < 0. 1

## Table 5- Probit estimation of unused play patents - Average marginal effects

| Variables | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Triples (mean) | | | | | 0.001*** |
| | | | | | (0.000) |
| Technological Uncertainty | 0.347*** | | 0.225*** | 0.206*** | 0.253*** |
| | (0.091) | | (0.066) | (0.066) | (0.096) |
| Technological Complexity | 0.052*** | | | 0.020** | |
| | (0.013) | | | (0.010) | |
| Propriety year- 2004 | | 0.006 | 0.006 | 0.006 | 0.006 |
| | | (0.010) | (0.010) | (0.010) | (0.010) |
| Propriety year- 2005 | | 0.004 | 0.005 | 0.005 | 0.005 |
| | | (0.012) | (0.012) | (0.012) | (0.012) |
| No. of inventors | | -0.001 | -0.001 | -0.001 | -0.000 |
| | | (0.002) | (0.002) | (0.002) | (0.002) |
| No. of claims | | 0.000 | 0.000 | -0.000 | -0.000 |
| | | (0.000) | (0.000) | (0.000) | (0.000) |
| No. of backward citations | | -0.000 | -0.000 | -0.000 | -0.000 |
| | | (0.000) | (0.000) | (0.000) | (0.000) |
| XY References | | -0.000 | 0.000 | 0.000 | 0.000 |
| | | (0.002) | (0.002) | (0.002) | (0.002) |
| Firm age 2-4 Yrs | | 0.011 | 0.010 | 0.010 | 0.014 |
| | | (0.031) | (0.031) | (0.031) | (0.032) |
| Firm age 5-10 Yrs | | -0.009 | -0.009 | -0.008 | -0.004 |
| | | (0.029) | (0.029) | (0.029) | (0.029) |
| Firm age 11- 20 Yrs | | -0.004 | -0.005 | -0.004 | -0.002 |
| | | (0.030) | (0.029) | (0.030) | (0.030) |
| Firm age > 20 Yrs | | -0.008 | -0.007 | -0.005 | 0.002 |
| | | (0.027) | (0.027) | (0.027) | (0.027) |
| D-Miss- Firm age | | -0.154*** | -0.153*** | -0.153*** | -0.151*** |
| | | (0.016) | (0.016) | (0.016) | (0.017) |
| Firm size 50-99 empl | | 0.007 | 0.006 | 0.007 | 0.006 |
| | | (0.033) | (0.033) | (0.033) | (0.033) |
| Firm size 100-249 empl | | 0.004 | 0.004 | 0.006 | 0.005 |
| | | (0.027) | (0.028) | (0.028) | (0.028) |
| Firm size 250-499 empl | | -0.025 | -0.026 | -0.026 | -0.028 |
| | | (0.026) | (0.026) | (0.026) | (0.026) |
| Firm size 500-999 empl | | 0.036 | 0.036 | 0.036 | 0.033 |
| | | (0.030) | (0.030) | (0.030) | (0.030) |
| Firm size 1000-4999 empl | | 0.050** | 0.050** | 0.049** | 0.045** |
| | | (0.024) | (0.024) | (0.024) | (0.024) |
| Firm size 5000-9999 empl | | 0.103*** | 0.102*** | 0.100*** | 0.094*** |
| | | (0.018) | (0.018) | (0.018) | (0.018) |

| | | | | | |
|---|---|---|---|---|---|
| JP | | -0.007 | -0.008 | -0.006 | -0.009 |
| | | (0.062) | (0.061) | (0.062) | (0.058) |
| IL | | -0.008 | -0.008 | -0.007 | -0.011 |
| | | (0.081) | (0.080) | (0.081) | (0.077) |
| US | | -0.040 | -0.040 | -0.037 | -0.039 |
| | | (0.059) | (0.059) | (0.059) | (0.055) |
| EP | | -0.022 | -0.020 | -0.016 | -0.016 |
| | | (0.061) | (0.061) | (0.061) | (0.057) |
| Observations | 8245 | 8245 | 8245 | 8245 | 8245 |
| Pseudo R-squared | 0.0032 | 0.0253 | 0.0265 | 0.0270 | 0.0291 |
| Prob > chi2 | P <0.001 | P <0.001 | P <0.001 | P <0.001 | P <0.001 |
| Log liklihood | -4098.58 | -4008.0186 | -4003.08 | -4000.70 | -3992.0873 |
| Wald chi -square | 27.66 | 168.71 | 181.38 | 183.56 | 197.32 |

Notes: Robust standard errors are in parentheses, adjusted for clusters by firms' identifier.
All models include dummies for missing values for firm age and missing values for XY References. Regressions also included additional control variables for technological classes and industry classifications *p<0.1, ** p<0.05, *** p<0.01

# Chapter III

## Patent nonuse: are patent pools a possible solution?

## Abstract

Studies have depicted that the rate of unused patents comprises a high portion of patents in North America (35% Non-use on average), Europe (37% Non-use on average) and Japan (64% Non-use on average). The importance of the issue of nonuse is also highlighted within the literature on strategic patenting, IPR policy and innovation economics and in this regards, the literature has paid particular attention to blocking patents. Moreover, the current literature has emphasized on the role of patent pools in dealing with potential issues such as excessive transaction cost caused by patent thickets and blocking patents (overlapping IPRs) that might hamper the use of patents in the market for technology. Accordingly, patent pools may favor the use of the pooled patents through decreasing licensing transaction cost and providing equal and non-discriminatory access of all the members and potential licensees to the pool's technology. Hence, companies willing to license their patents through patent pools might consider taking advantage of faster, easier, broader and less costly access to the pool licensees. Nevertheless, in this study we argue that the willingness to use patents through pool participation by a pool member is not limited to the use of those patents that it includes in the patent pool. Becoming a member of a patent pool may also favor the use of blocking and non-blocking patents held by a pool member outside the pool (non-pooled patents) by providing the opportunity to use the patent internally or externally in collaboration with other members. Using the data from a large scale survey on European inventors of 22,533 EPO patents resident in Europe, USA, Japan and Israel (PatVal II) as primary data and a considerably large database of patent pools in telecommunication and consumer electronics industries as secondary data, in this study we show that pool members participating more intensively in patent pools are more likely to be willing to use their non-pooled patents through pool participation. Furthermore, we show that pool licensors are more likely to be willing to use their non-pooled patents by participating in patent pools with higher level of technological complementarity to their own technology. This study contributes to the current discussion on social, economic and technological benefits of patent pools. The results of this study have practical implications for strategic decision-making and for policy makers dealing with the issue of patent nonuse, overlapping IPRs and cumulative innovations.

Keywords: Patent nonuse, Patent pools, technology commercilization

## 1. Introduction

During the last decade the issue of patent nonuse has got attention by economics and management scholars. This is firstly due to the fact that although patents are considered as firm's valuable assets, a high share of patents is left unused within the companies' patent portfolios. Studies have depicted that the rate of unused patents comprises a high portion of patents in North America (35% Non-use on average)[3], Europe (37% Non-use on average)[4] and Japan (64% Non-use on average)[5]. Moreover, even early records have also shown a high rate of unused patents particularly in North America. An Economic Review of the Patent System 12 (Study No. 15 of the Subcommittee on Patents, Trademarks, and Copyrights of the Senate Committee, 1958) reports an estimation of between 80 to 90% of all patents which are neither used nor licensed out. According to Chesbrough (2006), in the past the rate of patent commercialization has been determined for multinational companies such as Procter & Gamble about 10% and Dow Chemical about 19%. A report by The Economic Council of Canada (1971) also shows that out of the total number of patented inventions granted in Canada in the period of three years of the survey, only 15% have been used in Canada and 48 % are used outside this country. A study by Palomeres(2003) also provide evidence that more than half of the IP portfolios of companies such as IBM, Siemens and Philips are left unused. In general, it is reported that non-use of patents consisting of internal non-use as well as not licensing out or not selling comprises a share of higher than 35% of companies' patent portfolios (BTG, 1998, Giuri et al., 2007).

There are also theoretical arguments within strategic management, IPR policy and innovation economics literature which highlight the importance of studying this issue. First of all, since patents are basically used as means of protecting inventions, they have the potential to create monopoly power for their owner (Feldman,2008) and therefore if patents are not used they support the monopoly without providing any social and economic benefits since the innovations based on those patents are not eventually exploited. Accordingly, for a better and more efficient

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3 Nagaoka, S., and J. P. Walsh. 2009. Commercialization and other uses of patents in Japan and the US: Major findings from the RIETI-Georgia Tech inventor survey. RIETI Discussion Paper, Tokyo, Japan. Research Inst. of Economy, Trade and Industry.

4 Giuri et al., 2007. Inventors and Invention Processes in Europe. Results from the PatVal-EU survey. Research Policy 36, 1107-1127.

5 Japanese Patent Office (JPO) (2004), "Survey Results on Intellectual Property: Related Activities", Power Point Presentation, JPO, Tokio.

exploitation of resources and also from a policy perspective, studying the issue of patent nonuse is of high importance. In fact a share of patents are not used since they have no value (Rivette and Kline 2000), however, the importance of the issue of nonuse arises when the unused patent encompass value. A share of patents is not used because they have been filed for purely strategic purposes. This includes protecting firm's core technology when the firm tries to file patents in order to create a protecting boundary around its core business (Cohen, Nelson and Walsh, 2000), obtaining freedom to operate (Grindley and Teece, 1997;Hall and Ziedonis 2001; Ziedonis 2004;Blind, Edler,Frietcsh, and Schmoch 2006), signaling company's strength for potential infringement law suits particularly for larger companies that have patents very close to those of small companies and just patent to signal their power and not to use it in a product, to obtain negotiation power in cross licensing agreements (Cohen et al, 2000;Cohen et al 2002) and not necessarily these patents will be finally a part of cross-licensing agreements and therefore will be left used. A patent also might not be used due to its owner's strategic purposes such as preventing the negative market effect of own innovation on existing products or preventing rivals' entry into the market (Gilbert and Newbery,1984).These will create unused patents which might be of high value. In fact, development of innovation can be negatively affected by the existence of strategic use of patents as subsequent inventions can be limited by fundamental ones which restricts the pace and even direction of the innovation (Cohen, 2004). According to Scotchmer(1991), in cumulative technologies where inventions are built upon each other, the incentive of second round innovators which are building their innovation on the basis of the first round inventions will be affected by the risk of probable patent infringements lawsuits. A patent which is not used in order to prevent entry of competitors into the market obliges the new entrants to pay extra costs of inventing around such patent, pay royalties to the patent owner, or accept probably strict ex-post fines (Harhoff, et al., 2007). Patent races, are also the consequence of strategic importance of using patents in which marginal innovation is the basic motivation for patenting. Diffusion of the technology will be also hindered by the existence of unused patents.

Unused patents are broadly defined as those patents which are neither used internally for commercial or industrial purposes nor used externally through licensing out or selling to third parties (Palomeras, 2003). Therefore, if a patent is not used in an internal commercialization process or externally through licensing (cross-licensing), sale or spin-off it can be considered as an unused patent (Giuri and Torrisi, 2011, Torrisi et al., 2014). The literature has distinguished between the two types of unused patents namely, sleeping and strategic (mainly blocking) patents. There are several strategic motives behind developing an invention discussed by the literature, nevertheles not necessarily all of them will result in unused strategic patents. Furthermore, these motivations vary across different technological fields and as a result may generate different shares of unused patents across different industries.

Besides studying patent nonuse the literature has also proposed some solutions in order to tackle the social and economic issues caused by them and in this regard the most attention has been paid to issues caused by blocking patents. In fact, the current literature has emphasized on the role of patent pools in dealing with potential issues such as excessive transaction cost caused by patent thickets and blocking patents and overlapping IPRs (e.g. Carlson, 1999; Shapiro, 2001) that might hamper the use of patents. Patent pools are defined as "[…] an agreement between two or more patent owners to license one or more of their patents to one another or third parties"(USPTO, 2000).

The convergence between strategic patenting literature and patent pool studies identifying the benefits related to patent pools however, does not exceed some theoretical papers concerning the role of patent pools in decreasing the transaction cost associated to licensing of blocking patents (Carlson, 1999; Shapiro, 2001 ; Merges, 1999), providing equal access of all the pool members to these patents (Sung and Pelto, 1998) and very few empirical studies concerning the role of pools in decreasing the rate of strategic patenting in the market for technology (Lampe and Moser, 2014). There exists particularly a lack of empirical analysis on the relationship between pool participation and facilitation of patent use perceived by companies. We cover this gap, extending the theory on the patent commercialization benefits associated to pool participation perceived by firms involved in the market for technological standards to the commercialization of the patents held by a pool member out of the patent pool.

In fact, patent pools have emerged as policy tools facilitating technology commercialization and alleviating patent litigations among rivals holding overlapping IPRs. Accordingly, patent pools may favor the use of the pooled patents through decreasing licensing transaction cost and providing equal and non-discriminatory access of all the members and potential licensees to the pool's technology. This might be seen by companies involved in technology markets with excessive transaction cost and high IPR fragmentations as an opportunity to exploit their patents through participating in patent pools. As a matter of fact, companies willing to license their patents through patent pools are taking advantage of faster, easier, broader and less costly access to the pool licensees (technology implementers). Nevertheless, in this study we argue that the willingness to use patents by a pool member involved in high fragmented IP markets is not limited to the use of those patents that it includes in the patent pool which will be automatically licensed out after inclusion.  Becoming a member of a patent pool may also favor the use of blocking and non-blocking patents held by a pool member outside the pool (non-pooled patents) by providing the opportunity to use the patent internally or externally in collaboration with other members. Such an effect can be the result of mechanisms provided by the patent pool including greater access to the pool's complementary technology for members, formal collaboration inside the pool and informal collaboration outside it, changes in members strategies as a result of pool membership, enhanced information sharing and increased technological spillover , partnership opportunities and greater access to other parties' complementary assets and broader and less costly access and connections to the technology implementers (licensees). Considering such potential mechanisms favoring the use of non-pooled patents held by a pool member, in this study we empirically examine if participation intensity in patent pools by pool members explains their willingness to use their non-pooled patents. Furthermore, we investigate which characteristics of the patent pools are associated to the willingness to use non-pooled patents through pool participation.

To test our hypotheses we use the data from PatVal II Survey on European inventors of 22,533 EPO patents resident in Europe, USA, Japan and Israel with propriety dates between 2003 and 2005 conducted within the 7FP InnoS&T project between 2009 and 2011 as primary source of data and our database of 24 patent pools in telecommunication and consumer electronics industries including 21476 cross-country patents from 96 patent offices around the world as our secondary source of data. We focused our analysis on pool members that joined the patent pools between 2003 and 2011.  The PatVal II Survey, asks among other things if a patent is used and if not used yet, is its owner willing to use it.

We show that pool members participating more intensively in patent pools are more likely to be willing to use their non-pooled patents through pool participation. Furthermore, we show that pool licensors are more likely to be willing to use their non-pooled patents by participating in patent pools with higher level of technological complementarity to their own technology. In particular, this study contributes to the current discussion on social, economic and technological benefits of patent pools. We show that companies involved in highly fragmented IP markets, do not only see participation in patent pools to get the opportunity to facilitate their patent (technology) commercialization process by introducing their patents to the pool, as in the absence of a pool they can't use their technology without infringing on their competitors' patents. They also see pool participations as a way to facilitate the use of their unused (non-pooled) patents which have not been included in the pool. Moreover, in order to contribute to the better understanding of how pool participation explains the willingness to use non-pooled patents we investigated those characteristics of the patent pools which are associated to the willingness to use these patents through participating in patent pools. The results of this study have practical implications for strategic decision-making and for policy makers dealing with the issue of patent nonuse, overlapping IPRs and cumulative innovations.

The rest of the paper is organized as follows. In section 2 we present the literature review on patent nonuse and patent pools, discuss the theoretical background in more details and develop our hypotheses. In the third section the data collection and the descriptive statistics will be presented. In section 4 the empirical methodology of the study along with our results will be discussed. In section 5 we review the main findings and discuss the study's implications for the managers, policy makers and researchers.

## 2. Literature review

*2.1 Unused patents*

Patents can be either used internally in a new products or process or externally through licensing (or cross-licensing), sale, spin offs or joint ventures. The market for technology is the place in which companies can make revenues from patented inventions through licensing royalties or by patent sales. Nevertheless, the external use of patents through sale or licensing out is becoming more common in time since first, contractual uncertainty in the market for technology is decreasing as a result of the continues enhancements of patent rights enforcement and second, the emergence and growth of online markets for patents has generated new channels for patent trade (Palomeras, 2003; Dushnistsky and Klueter, 2011). Moreover, use of patents in cross-licensing agreements as another form of external use of patents is particularly common in cumulative industries wherein the likelihood of holding all patents required for a product by a single firm is very low. Another form of external use is Spin off. Spin offs which can be either voluntary or involuntary (Buenstorf, 2007;Klepper, 2009), are normally external utilization of patented innovation by universities and other research institutions which usually lack complementary assets in order to reach to the market. Joint venture by the use of patented inventions is also another form of external use of patents. If a patent is not utilized in at least one of the aforementioned ways it is considered as an unused patent(Giuri and Torrisi, 2011, Torrisi et al., 2014).

In an attempt to provide a more precise definition for unused patents the literature has distinguished between sleeping and strategic patents as the two types of unused patents. Sleeping patents are defined as those patents which are left completely unused and unexploited for reasons other than strategic purposes, while strategic patents are those which are deemed to be used strategically by the patent owner (Palomeras, 2003). In fact, sleeping patents are a result of the patent owner's failure in commercializing his patent when there is no enough present commercial value for the patent or when the patentee's attempt in order to license the patent fails (Turner, 1998). Sleeping patents are those which are left completely unused for reasons other than strategic purposes. Sleeping patents have the potential to be utilized at some point in time by the patent holder or other parties provided that the cost of exploiting the sleeping patents is rational or it is not complicated to utilize them. Strategic patents are deemed to be used strategically by the patent owner and therefore generate strategic rents for their owners through blocking rivals or protecting the company's existing assets. According to Harhoff, et al., (2007) "Strategic use of the patent system arises whenever firms leverage complementarities between patents to attain a strategic advantage over technological rivals. This is anticompetitive if the main aim and effect of strategic use of the patent system is to decrease the efficiency of rival firms' production." Different studies have shown that the strategic use of patents is one of the most important reasons behind forming large patent portfolios by companies in a number of industries (Cohen, Nelson and Walsh, 2000; Hall & Ziedonis, 2001; Bessen & Hunt, 2004).

Blocking is one possible strategic use of patents by which the owner of an IPR intends to impede rivals from using their invention. According to the literature, strategic use of patents might be intended to fence with the aim of prevention of imitation by competitors (Cohen et al, 2000), particularly by firms encompassing huge patent portfolios which are more willing to exclude their competitors by making a protecting boundary around their core technologies by patenting several substitute inventions (Cohen et al, 2002;Davis, 2008; Jung, 2009). Fence patent are in general very unlikly to be used by their owner(Cohen et al., 2000). Strategic use of patents might also be intended to play that is generally aimed for creating a credible insurance against probable infringement lawsuits threatening the company's inventions, and achieving negotiation power in cross-licensing agreements (Cohen et al, 2000;Cohen et al 2002). Play patents might be used in a cross-licensing (or licensing) deal or even commercialized, however if they are filed to block competitors or are held in order to tackle possible future litigations are very unlikely to be used in an internal commercialization process or externally. Moreover, those play patents filed to be employed as bargaining chips might be left unused due to the barraging failure between the parties.

*2.2 Patent pools*

The term "patent pool" is defined in the literature by some studies. USPTO (2000), defines patent pools as "[…] an agreement between two or more patent owners to license one or more of their patents to one another or third parties". Merges (1999), defines a patent pool as: "A patent pool is an arrangement among multiple patent holders to aggregate their patents. A typical pool makes all pooled patents available to each member of the pool. Pools also usually offer standard licensing terms to licensees who are not members of the pool. In addition, the typical patent pool allocates a portion of the licensing fees to each member according to a pre-set formula or procedure." Kelin (1997) also defines patent pool as "…the aggregation of intellectual property rights which are the subject of cross licensing, whether they are transferred directly by patentee to licensee or through some medium, such as a joint venture, set up specifically to administer the patent pool"

In general, patent pools require essential patents to be implemented into the practice of a technological standard. Shapiro (2001), defines an essential patent as a patent which is claimed as an invention which must be utilized in accordance with a technological standard. He argues that blocking patents are particularly common in the context of standard settings implying that once a standard is chosen any patent which is necessary in complying with that standard becomes truly essential. Even though, patent pools necessitate inclusion of essential patents, in reality not all the patents included in the pools are essential to the pool's technology. Indeed, companies with more bargaining power within the pool might also include non-essential or even substitute patens in the pool. Patents pools composed of mostly complementary essential patents can decrease the issues caused by blocking patents (Carlson, 1999) or stacking licenses (Heller and Eisenberg, 1998). Staking licenses is an issue that a licensee may face in order to develop a product which requires licenses from all the licensors that hold the patents necessary to develop that product. In fact, this causes a combined royalty payment issue which may make the product unprofitable and therefore the licensee fails to take it in to the market.

Patent thickets are broadly defined as "a dense web of overlapping intellectual property rights that a company must hack its way through in order to actually commercialize new technology" (Shapiro, 2001) which cause overlapping and blocking rights. There are different features of patent thickets discussed in the literature such as cumulativeness of innovation, defined as the degree to which the innovations in an industrial sector are linked with or build on each other and concentration of patent ownership (Noel and Schankerman 2006, Cockburn and MacGarvie

2011).Patent holders who possess overlapping or blocking patents and are not able to develop the underlying technology unless being involved in infringing each other's patents try to establish formal or informal organizations with the aim of administering a patent pool or alternatively they may collaborate with one another in a cross-licensing agreement. Indeed, patent pools as cooperative mechanisms can help firms involved in the pool agreement to concentrate on their core competencies, since they can use other parties' technologies in order to develop their innovation and as a result from the social and economic point of view the innovation process will reach a higher speed of development (Shapiro,2001).The role of patent pools as a solution to these issues was initially proposed by Merges (1999), Shapiro (2001), and the U.S. Patent and Trademark Office by Clark, Piccolo, Stanton, and Tyson (2001), where for-profit companies share patent rights with each other and third parties, given that the relationship between patents involved in the patent pool is complementary. From this point of view patent pools are addressed as economically significant institutions. In fact, patents with complementary relationship are those which have more value if they are collected jointly in a single patent portfolio. Indeed, the necessity of patent pools for firms involved in industries with higher level of technological complexity is more comparing to industries with discrete underlying technologies since first, patent pools facilitate the access to complementary patents which are necessary for firms in order to develop their products and second, as the fragmentation of intellectual property rights and technological interdependencies is higher in these industries, the influence of patent pools in decreasing the transaction cost in the market for technology for these industries seems to be higher. For example, according to Merges (1996) in United States radio, aircraft, and automobile are examples of complex technologies which are developed based on patent pools.

It is worth mentioning that albeit patent-pooling agreements have potential to generate positive impact on firms' innovative activities and produce significant efficiencies when the patents relationship is complementary and freedom-to-operate is achieved by the parties, they can also create negative influences on firms' innovative activities and competition when the patents relationship is substitutive which results in blocking activities by the firms involved in patent pools by limiting the access of potential rivals and new entrants to the pool's technology and the market. Therefore, patent owners involved in a pool may also demonstrate anti-competitive behaviors such as restricting competition among the licensors that take part in the pool, using the patent pool as a price-fixing mechanism, forcing the licensees to pay for patents that they usually would not have chosen, restricting non-participating patent holders which own patents that are substitutes to the patents included in the pool, restricting competition in downstream products which contain the pooled patents or in other markets that are somehow linked to those, restricting the accessibility of patents that are technically or economically necessary for those other standards; and eliminating incentives for subsequent innovations (Bekkers, Iversen, and Blind, 2006). In fact, along with the pro-competitive effect of patent pools, their anti-competitive influences are also addressed by some studies in the literature. For example, Shapiro (2001) argues that the impact of patent pools on welfare will be positive when patents have a complementary relationship and will be negative when patents have a substitutive relationship. Considering both pro-competitive and anti-competitive effects of patent pools some models are presented within the literature mostly addressing the social welfare issues. For instance, through a model presented by Lerner and Tirole (2003) necessary and sufficient condition for a patent pool is provided in order to increase welfare. This model is extended in a number of directions in an attempt to provide an analysis of different patent pool related issues consisting of the external test evaluation which prevents substitute patents to be included in a patent pool, the inducement of the firms involved in a pool to do inventions around each other patents and the underlying principle meant for the provision of future-related patents' automatic transfer to the pool. Nevertheless, the full range of relationships among patents including perfectly substitutable and perfectly complementary patents are encompassed in a model presented by Choi(2010) which is developed on the basis of the Lerner and Tirole (2003) framework. He argues that the relationship between the pool's patents influences the public policy scope. Hence, patent pools are pro-competitive when the relationship is rather complementary for patents, implying the perfect alignment of private and public incentives to form the pool, while pools consisting of patents with substitutive relationship are inclined to be anti-competitive, implying a discrepancy among the social and public policies in forming the pool.

### *2.3 Hypotheses development*

The benefits associated to patent pools are not limited to reducing the issues caused by blocking patents (Carlson, 1999), stacking licenses (Heller and Eisenberg, 1998) or patent thickets (Shapiro, 2001). There are other benefits related to patent pools, which can further address the issue of blocking patents. In a number of industries, there exist too much IPR fragmentation and technological interdependencies in which several patent owners are controlling the patent rights needed for commercializing a product. This raises the transaction costs for negotiating more licenses and brings about increased cumulated royalties. Nevertheless, although this may increase the costs to bring products to the market, the trade of intellectual property rights is of high importance to the industries which provide complex products and as a result finding some solutions for this issue is of great importance from economic and social point of view. Indeed, another advantage associated to patent pools discussed in the literature is reducing licensing transaction costs (Merges,1999;Clark, Piccolo, Stanton, and Tyson, 2001). This is due to the fact that first patent pool agreements decrease the litigation and disputes among patent owners to a high extent which can considerably reduce the cost, time and uncertainty about intellectual property rights associated to patent litigations. These seem to be more crucial to firms with relatively small size as they are basically not able to afford the cost of patent litigation. Second, patent pools provide the opportunity for licensors involved in a pool covering a core technology to license all the necessary patents through one agreement without needing to do one by one licensing (Clark, Piccolo, Stanton, and Tyson, 2001), that apart from the cost, time and resources required can also create the risk of hold ups by other patentees in licensing patents. As a matter of fact, a patent pool enables interested parties to bring together all the essential tools for practicing a certain technology in one place, e.g, "one- stop shopping," rather than acquiring licenses from each patent holder separately[6]. Therefore, patent pools can decrease the transaction cost in the market for technology by creating a single access point which leads to lower searching cost, lower uncertainty, increased transparency and accelerated access (Bekkers, Iversen, and Blind, 2006). Lowering the licensing transaction cost will intensify the rate of use of the blocking patents which are included in the patent pool.

The equal access of all the pool members to the patent pool’s technology can be considered as another advantage of patent pools which can increase the patents commercial potential (Sung and Pelto, 1998). Patent pools can also warrant equal access of their members to all potential licensees (Bekkers, Iversen, and Blind, 2006). Therefore by providing pool members’ equal access to each other’s patents as well as to potential licensees, patent pools eliminate discriminatory accessibility of patents and make them available to use for all their members. This can help to intensify the rate of use of blocking patents included in the pool as a result of more accessibility of the patents.

Information sharing is another benefit associated to patent pools (Merges, 1999; Clark et al, 2000). According to Clark et al, (2000), patent pools provide their members with “institutionalized exchange of technical information” which is not covered by patents. As a result of collaborating and communication with each other in the technological area covered by the patent pool, pool members will get access to technical information related to the patented technology. Furthermore, the information about non-patented inventions will be also transferred

[6] US Patent and Trademark Office, "USPTO issues white paper on patent pooling", Jan. 19, 2001.

among the patent pool members (Merges,1999). These will provide the licensors and the licensees with information sharing mechanism advantage that in turn decreases the probability of working on overlapping inventions which are a source of blocking patents. Therefore, patent pools can lower the rate of blocking patents in the market for technology either by intensifying the rate of use of blocking patents which are included in the patent pool by decreasing the transaction cost and providing equal and non-discriminatory access of all the members and potential licensees to the pool's technology or by preventing strategic behaviors by the pool members and decreasing the probability of working on overlapping inventions. From a firm's perspective, however lower transaction cost and equal and non-discriminatory access to other members technology and the licensees can be seen as important benefits that could facilitate its technology commercialization process which affects the firm's willingness to exploit its patents through pool participation particularly if it is facing any difficulties in commercializing its technology. However, the benefits provided by patent pools and therefore the effect of patent pools on the rate of use of patents may not be limited to the blocking patents which are included in the patent pool. Patent pools may also affect the rate of use of blocking and non-blocking patents, which are not included in the pool and are owned by patent pool members within the same or different technological classes from those of patent pools (non-pooled patents).

The number of non-pooled patents in those ICT-based technologies where the formal ICT standardization process is an ex-post process developed by standard setting organizations is considerable. This is due to the fact that in developing such formal standards the companies have been involved in costly R&D rivalries prior to the standard selection process, developing competitive technologies out of which, only a portion will be finally evaluated as essential patents to the standard by the ad hoc working groups (or entities). This is as opposed to an ex-ante process where the development of the technology and the standard happens concurrently with the ex-ant contracting among the companies involved in developing the standard (Ganglmair & Tarentino, 2011). Therefore, the number of non-essential patents is expected to be lower in the technological standards resulting from ex-ant consortia formed by firms on account of a prior clearer and better commonly managed technological roadmap by the parties.

Regardless of its type (blocking, partially blocked , or sleeping), a non-pooled patent which has enough value and is left unused can be used in an internal commercialization process or externally through cross-licensing or licensing agreements or sale conditioning upon its owner's willingness to use it. Accordingly, in this study we argue that participation in patent pools not only explains the willingness to use the patents which a licensor includes in a pool, but it also explains the willingness to use non-pooled patents as becoming a member of a patent pool may also favor the use of non-pooled blocking and non-blocking patents held by the pool member through providing the opportunity to use the patent internally or externally. Below, we discuss the mechanisms through which patent pool membership might favor the willingness to use non-pooled patents through pool participation by a member.

***( i ) Technological complementarity***

A valuable sleeping or strategic patent that is left unused but its owner is willing to commercialize it internally might be left unused due to the firm's lack of access to complementary technologies. Makri, Hitt, and Lane (2010) *define technology complementarity* as "the degree to which the technological problem solving focuses on different narrowly defined areas of knowledge within a broadly defined area of knowledge that they share". In their approach *technology complementarity* is operationalized as the overlap in patents in the same subcategory but in a different class. Their definition addresses the technology complementarity within a value chain activity versus asset complementarity across different value chain activities. By joining a pool a company might get access to complementary technologies necessary for commercializing its patent (within the same value chain). However, contingent upon the complementarity between the firms' patents and the patent pool patents a patent pool might affect the propensity to use non-pooled patents as a result of providing complementary technologies necessary to exploit the patent. Such complementarity is excepted as in general a patent pool increases the interoperability of a member's technology with those of others. A non-pooled patent which is left unused due the lack of access to the complementary technologies might be used as a result of the firm's membership in a pool that is contributing to those complementary technologies, benefiting from full access and lower transaction cost. Therefore, a valuable non-pooled patent that is in the same technological filed of the patent pool but in a different technological class from the main technological class of the pool (has a complementary relationship with pool's technology) can be exploited by its owner's access to the complementary technologies provided by the patent pool. Moreover, becoming a member of a patent pool that is covering a technological standard can give the opportunity to a firm to navigate the technological development of the standard in a pathway which can lead to creation of a technology that is complementary to the firm's own installed IP base. Perceiving, such benefits affects a licensor's willingness to use its non-pooled patents through participating in patent pools with complementary technologies to its own technology.  Hence, the higher the level of technological complementarity of the pool to the firm's own technology, the more likely might be a pool member to be willing to use its non-pooled patents through participating in that pool. Therefore, we posit:

**H1)** *Patent pool licensors are more likely to be willing to use their non-pooled patents through participating in patent pools with higher level of technological complementarity to their own technology.*

***( ii ) Information spilover and collboration***

A valuable sleeping patent whose owner is waiting to receive further information in order to get the possibility to use it, can be commercialized if such information (and knowledge) can be acquired from other pool members in the process of interacting and collaborating with them within a patent pool. Patent pools decrease the communication cost among their members and lower search and information cost between them. According to the literature, lower communication cost leads to higher level of collaboration among parties (Agrawal and Goldfarb, 2008; Jones, Wuchty, and Uzzi 2008; Adams, Clemmons, Black, and Stephan 2005). In fact, the information sharing mechanism which is a result of formal collaboration with the patent pool discussed as another benefit associated to patent pools (Merges,1999; Clark et al. ,2000), may help a firm to acquire further information and knowledge required for exploiting an invention. It also might help the firm to find new and better ways of commercializing its unused patent through learning from other members by having the possibility to collaborate with them within the patent pool in the process of creating and developing the pool's technology. Indeed, the collaborative learning mechanism provided by the patent pool may increase the knowledge of each individual member about technological possibilities and opportunities in the technological field of the patent pool. Even if a pool member has not a significant or equal role in developing the pool's technology with other members, joining a patent pool provides her with the possibility to be up-to-dated about the technological development of the pool which might help her in exploiting her invention.

The literature on organizational learning argues that the knowledge acquired form others can be divided into product knowledge and process knowledge (Kogut and Zander 1992; Rindfleisch and Moorman 2001). Such knowledge makes the owner of a non-pooled patent aware of new internal or external ways for exploiting her patent outside the patent pool. Direct communication among patent pool members engaged in further product development of a pool increases the spillover among the members of the patent pool. As a matter of fact, the information sharing advantage associated to patent pools affects downstream product development for the pool members through the spillover effect among them in the procedure of developing a marketable product. Marshall (1920) identifies technological spillovers which are a result of information exchange as one of the sources of positive externalities among firms. Indeed, considering the theoretical arguments provided by the literature on the concept of technological (R&D) spillover patent pools can be considered as collaborative licensing mechanisms which can increase spillover among their members, however the level of the spillover might vary across patent pools and their members. Steurs (1994) defines R&D spillover as "R&D spillovers refer to the involuntary leakage, as well as, the voluntary exchange of useful technological information". Grossman & Helpman (1991) define spillover as "By technological (or R&D) spillovers we mean that a firm can acquire information created by others without paying for that in a market transaction". According to Jaffe (1986, 1989) the magnitude of knowledge spillovers is a function of the technological distance between firms. Although patent pools are not expected to affect the technological distance between firms, firms involved in developing the same technological standard of a pool are expected not to be technologically far. Therefore companies participating in the same pool are expected to have higher knowledge spillover as compared to other companies that develop their technologies independent or in collaboration with very limited partners. The literature also provides evidences that there is a positive relationship between specialization (as opposed to diversity) and knowledge spillover (Saxenian, 1994). Since in contributing to the pool's technological standard development licensor are mostly specialized in the same technology a higher spillover is expected to exist among them. These all may increase the possibility of commercializing a patent with enough value to the market since the owner may learn new ways of commercializing her patent internally and externally. All these possibilities will be raised particularly when a company is mainly operating in the same technological filed of the patent pool in collaboration with others.

Furthermore, firms with in-house innovations might try to complement their activities in collaboration with others. In this regard, they might also seek collaboration with their competitors. Particularly, in case of developing technological standards, firms are typically involved in collaborative innovation activities within a patent pool. Such collaboration might have been started even before formation of a pool through consortia or after its formation through standard setting organizations or quasi-formal standard bodies. Although firms usually collaborate even in the absence of a patent pool, by participating in a pool a firm might expect collaboration with others on a broader scale. As collaboration often necessitates considerable coordination costs and brings about potential moral hazard, joining a pool might also help a firm to reduce the associated costs and risks as a result of the pool's cost and risk sharing benefit.

Therefore patent pools can be also seen as mechanisms which can facilitate formal collaboration among their members. However, the intensity of collaboration might differ across firms and patent pools. The possibility to have formal collaboration inside the patent pool may also provide the opportunity for members to have informal collaborations outside the pool in the same or other related technological fields not covered by the patent pool. This can also increase the probability of use of a non-pooled patent since the patent owner may find new ways and better opportunities for commercializing her valuable sleeping patent through some informal collaboration out of the pool. Moreover, this might affect the use of a non-pooled patent that is left unused as a result of being blocked by the firm's competitors. If the competitor is a pool member, by joining a pool the company might find an easier and less costly way to have an agreement with its rival and therefore as a result of this agreement use the patent outside the pool.

A valuable sleeping patent might have been also left unused due to the firm's lack of access to complementary assets or due to the fact that it has not found a partner that might have the necessary complementary assets in order to exploit the patent yet. The possibility to interact with other members within the patent pool might give the opportunity to a firm to recognize the technological capacities of other members particularly in terms of their manufacturing capabilities. A firm with lack of complementary assets to commercialize its valuable patent might find a pool partner (across another value chain) owning the required complementary assets that is able to use its patent in a product or process. Therefore, holder of a non-pooled sleeping patent that is left unused due to the lack of complementary assets will be able to exploit her patent by finding a partner through joining a patent pool. Particularly, if a patent belongs to a sector where the company is not present, by joining a patent pool that is contributing to that sector the company might get better opportunities to use that patent.

Collaborating in process of technological development of a standard in dialogue with others within the patent pool and acquiring further knowledge for more beneficial exploitation of a patented invention, might also affect the firm's strategies. A valuable strategic patent that is left unused intentionally due to strategic reasons might be actually exploited by its owner as a result of the change in the firm's strategy after joining a patent pool although it has been initially filed for blocking purposes. In fact, a firm might find the monetary rents out of the patent superior to its strategic rents at a point of time after joining the pool, since the pool might offer better opportunities for exploiting the patent in a non-strategic way. Moreover, patent pools decrease anti-competitive and strategic behaviors among their members (Lampe and Moser,2014) to a considerable extent and therefor increase competition between them (Vakili, 2012) which consequently decreases the propensity of strategic non-use of patents by pool members.

In particular, the decision to earn monetary rents instead of strategic ones is more likely to be made by vertically integrated firms rather than research and development oriented firms as besides lowering the licensing transaction cost, in general pro-competitive pools of complementary patents decrease the aggregate license fee faced by manufacturers. Particularly, vertically integrated firms using the pool's standard essential patents in their products can benefit from less costly cross-licensing deals with other parties. R&D oriented firms are typically less likely to join a pool as their main source of revenue is licensing and they might earn higher royalties by licensing patents individually outside a pool considering that as specialized firms they hold especially valuable patents contributing to the standards that gives them the possibility to negotiate higher fees for their patents unmixed with less valuable patents held by vertically integrated firms (Layne-Farrar and Lerner, 2011).

*( iii )* ***Broader and less costly access to licensees***

A pool provides access to a larger number of licensees, which is a result of superior resources that a pool has in tracking and signing up the licensees as well as the larger size of the patent pool (as compare to a single licensor). Singing up licensees is very costly for a single firm; however for a patent pool signing up a limited number of licensees is feasible, as the substantial cost associate for setting up the pool is worn by all the pool members, the patent pool initiator and the pool administrator. As a result, a patent pool prepares a ground for its members to have access to a broader range of licensees and therefore establish informal connections with them outside the pool. Licensees might also seek further technological supports from pool licensors in developing their products beyond the technological coverage provided by the pool. In fact, the licensing packages provided by patent pools are limited to certain technological standards; however, in developing their products licensees might need further technologies, which are often provided by pool licensors out of the technological space of the pool as particularly in case of ICT pools, licensors are in general very large firms with broad technological capacities. Seeking further technological support might lead to broader informal collaborations among licensors and licensees outside of the pool. Broader informal collaboration outside the pool might increase the chance of using a non-pooled patent which has the potential to be licensed out or sold to other parties as discussed.

Hence, partnership opportunities and greater access to other parties' complementary assets, broader access and connections to the licensees (technology implementers), formal collaboration inside the pool and informal collaboration outside it, causing changes in members strategies, enhanced information sharing and increased technological spillover provided by the patent pool may help a company to use its non-pooled patents. Seeing such opportunities provided by the pool, a licensor might get more willingness to use its non-pooled patents through participating in patent pools more intensively. Firms as technology providers to a pool will have a higher intensity of participation if they introduce more patents into the pool out of their IP portfolio. The inclusion of a higher share of patents out of a firm's portfolio not only implies the willingness of the firm to commercialize its patents through the pool, but also shows the higher technological involvement of the firm in the pool's technological area. Companies, with higher technological capacities and engagement in the pool technological area are more also more likely to own non-pooled patents in the technological field of the pool or in related tech areas. Therefore, such companies recognizing the benefits provided by the pool are more likely to be willing to use the non-pooled patents through participating in pools more intensively.

Thus, we forward our hypothesis as:

**H2)** *Pool members participating more intensively in patent pools are more likely to be willing to use their non-pooled patents through pool participation.*

## 3. Data collection and descriptive statistics

With the aim of testing the hypotheses in this study primary and secondary data are employed conjointly. The primary source of the data for this study is PATVAL II database which is a cross-country database developed within InnoS&T project in 2010 and 2011, intended for studying the determinants of patent licensing, patent sale and new venture creation by firms, universities and PROs(Torrisi, et al, 2014). The survey collected information on inventors' education, invention process, inventors' motivations and rewards and use and value of patents by surveying inventors of 22,533 EPO patents with propriety dates between 2003 and 2005 resident in Europe (Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Sweden, Slovenia), USA, Japan and Israel, through employing a harmonized questionnaire across all the surveyed regions(Torrisi, et al, 2014). This data was compared with supplementary information obtained from other sources on the patent, technology, region and inventor. There are a number of indicators obtained through PatVal II database. The PatVal II

Survey, asks among other things if a patent is used and if not used yet, is the owner willing to use it.

## 3.1 Secondary data collection Procedure

### *3.1.1 Initial data collection*

### *3.1.2 Sample selection procedure*

As the main concern of this study is investigating the link between pool participation intensity and willingness to use non-pooled patents, a sample of patent pools is constructed as the secondary source of data. Our sample represents the industries with IPR-based (patent) standardization where the establishment of patent pools has been based around the technological standards. We particularly focus on telecommunication and consumer electronics industries due to the crucial role of patents in development of the technological standards in these two industries. In *telecommunication industry*, the protection of the R&D based inventions has been long provided by patents, and patent-based standardization has been prominently an issue in this industry. The industry more than any other one, is severely relying on patent-based standardization efforts mostly done by Standard Setting Organizations, where patent pools have been playing a crucial role in making the licensing practices more efficient and bringing the standard to the market in a faster, easier, less costly and non-discriminatory manner(e.g. 3G, 4G(LTE), WIFI patent pools). *Consumer electronics* industry which comprises standards for video and audio recording and compression as well as reproduction (e.g Mpeg and H.264 for audio and video), is also characterized by the dominance of major patent pools (e.g. DVD6C & ONE BLUE & BD Premier), where the establishment of the pool is basically done in consortia, rather than quasi formal standard bodies or Standard Setting Organizations. In most of the cases the consortia is formed by few dominant market players that hold patents essential to the related standard and later on the pool is administered by specialized pool administrators such as MPEG LA, SISVEL and Via Licensing.

The standardization efforts in both industries has been enhanced by the presence of patent pools, since the more efficient licensing of Standard Essential Patents has been provided by patent pools through lowering transaction cost including lowering search and information cost, contacting and bargaining costs and policing and enforcement cost. Patent pools in these industries also provide lower market uncertainty, lower license fees and lower degree of discrimination among licensees. All the licensing packages included in our sample are contributing to the complex technological fields were the overlapping IPRs and blocking patents have raised the necessity of formation of modern patent pools with the intention of decreasing transaction cost, and providing equal access of the pool members to the pool's technology. Until Second World War many patent pools in various technological areas were subject to non-essential or substitute patents. During 1997 and 1999 antitrust authorities in Europe and USA authorized a new model of patent pooling providing precautions against anti-competitive abuses through which the complementarity and essentiality of the patents in the pool should assure the legal certainty of the pooled patents. Accordingly modern patent pools which are an outcome of these efforts, are a proper context for our study as in general they consist of complementary and not substitute patents that are essential to the standard covered by the pool as argued. Furthermore, another important characteristic of the modern patent pools is the freedom of their licensors to license out their patents directly and not through the patent pool which gives the licensors the possibility to have formal and informal collaborations outside the patent pool which might increase the likelihood of use of a non-pooled patents as a result of the licensors' collaborations outside the patent pool.

### *3.1.3 Data cleaning and harmonization*

With the purpose of constructing the patent pool database and performing matching analysis between Patval II and the patent pool dataset in both firm and patent level, I cleaned, re-formatted and harmonized the collected data manually (including standardizing patent publication numbers and company names). I also cleaned and harmonized all the family patents for the patents in the PatvalII survey (totally 195,118 family patents) which was further used to perform the patent-level matching analysis between the patent pool dataset and PatvalII survey. The result of patent-level matching analysis was only 58 patents as our primary source of data includes patent with priority date 2003-2005 and our secondary data is limited to patents from ICT sector. Nevertheless, through the firm level matching analysis I found 37 companies from PatvalII participating in patent pools holding 2149 non-pooled patents. The final sample is thus composed of 2149 non-pooled patents belonging to 37 licensors that have joined the patent pools in our database.

### *3.1.4 Database construction*

I retrieved patent-level data corresponding to patent application, patent publication, inventor, citation, claim, technological class, title , abstract and patent family from PATSTAT online by issuing a series of SQL commands. Furthermore, for each licensor in my patent pool database, I collected firm-level information such as age, size, type, industry (SIC), country and competitors from various databases such as Amadeus, Lexis Nexis , Osiris and Hoovers. Additional variables such as date of each licensor's membership (in each pool), licensors' experience, no. of technological classes and no. of patent families per licensor are also constructed. I also collected patent pool-level information including patent pool administrator, pool age, pool size (no. of patents), no. of licensors, no. of licensees, no. of technological classes, no. of patent families and no. of licensing packages.

**3.1.5** ***Representativeness of the sample:*** Our sample represents 24 out of 52 modern patent pools (24 out of 33 modern patent pools with publically available patent data) in both industries and is considerably larger than any other sample of the patent pools studied (The largest sample studied consists of 9 pools by Delcamp 2012 and Layne-Farrar &Lerner,2011)[7]. Our sample represents 21476 cross-country and cross industry patents which have been participated in at least one of these patent pools, meaning that one patent might have contributed to more than one patent pool licensing package. In our sample of patent pools, patents are from patent offices from all around the world including, North America (US and Canada), South America, Europe (Austria, Belgium, Switzerland, Czech Republic, Germany, Germany, Spain, Finland, France, United Kingdom, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Sweden, Slovenia),and Asia (Australia, New Zealand, Japan, Thailand, Taiwan, South Korea, Malaysia, Singapore, China, India, etc). This data is mainly collected from patent pool packager (administrator) websites including Mpeg La[8], Sisvel[9] , DVD6c La[10], Sipro Lab. Telecom[11] ,ULDAGE[12] and One Blue[6]. Considering the wide range of the technologies covered by the patent pools in our sample, the considerable number of patents and the wide time span for the pool foundation date (from the very first modern patent pool to the very recent one), it can be argued that our sample of patent pools is a well representative sample for modern patent pools that is considerably larger than any other sample of the modern pools studied in the literature.

Our sample comprises all the patent pool licensing packages administered by One Blue (22 packages), DVD6C (42 packages), and ULDAGE (3 packages). Moreover, all the patent pools

[8]www.mpegla.com
[9] www.sisvel.com
[10] www.dvd6cla.com
[11] www.sipro.com
[12] www.uldage.com
[6] www.one-blue.com

administered by SIPRO Lab except for G.723.1, were also included in our sample. This exception is due to the unavailability of public patent level data for G.723.1 patent pool. SIPRO lab. has recently launched other pools namely AMR-WB AMR-WB+ and G.722 and are not included in our sample yet since the data was not available at the time of the data collection.

From Mpegla, all the patent pool licensing packages except for Librassay® are also included in our sample. This exception is also due to the unavailability of public patent level data for Librassay® patent pool. Moreover, out of the 14 patent pools administered by Sisvel, UHF-RFID, DECT, LTE, WIFI, TELEMTRY and DSL had no patent level data publically available at the time of the data collection and therefore were not included in our sample.

We have not included Medicine Patent Pool as the major non-profit and non-standard based pool among the pools serving discrete technologies, as the main concern of our study is to investigate the relationship between pool participation intensity and the willingness to use non-pooled patents. First, Medicine Patent Pool is a non-profit pool that is established with the aim of lowering transaction cost and preventing stacking licensing royalty problem to lower the cost of production of HIV/AIDS drugs and make them marketable in developing countries and therefore will not provide any strategic or extra monetary rents for its licensors. Second, no licensor is a member of this patent pool, because the pool is sponsored by public funds and by public pressure on licensors to cooperate in the pool and therefore it serves as a an independent agent that operates as an intermediate between the licensors and the licensees (Generic Medicine Producers). Therefore the pool is aimed to primarily fulfill general public interest and not serving private profitability, and as a result its objectives are much more in line with the objectives of the licensees and the public, rather than those of the licensors. Consequently, the decision to join this is not actually favored by the licensors and is more a matter of serving the public interests.

### 3.2 Analyzing (working) Sample

As explained before, out of our entire sample of pool participants, 37 licensors were covered by PatVal II survey which have entered into the pools between 1990 and 2012 and hold 2149 non-pooled patents. The date of entry to each pool by each licensor is collected form the pools' websites and if the date of entry was not found, the earliest publication date of its patents included in the patent pool was considered as a proxy of the entry time.

Out of the whole sample of non-pooled patents (2149 patents), our analyzing sample includes those held by the pool members that have joined a patent pool between 2003 and 2011 ($2002 <$ date of entry $< 2012$). We exclude patents held by licensors that have joined a patent pool before 2003 and after 2011, as our primary data consists of patents with priority dates 2003-2005 whose inventors were surveyed in 2010 and 2011. In other words, the relationship between a licensor's willingness to use its non-pooled patent(s) and our independent variables cannot be captured for non-pooled patents held by those companies that have entered pools out of this time span (2003-2011). This is due to the fact that first, the patent (or the invention's application filed to patent office) did not exist before 2003 and second we cannot capture the changes in use/non-use of the patent and its owner's willingness to use it after 2011. Out of the total non-pooled patents therefore, our analyzing sample includes 1300 patents held by 28 licensors participated in 15 patent pools. As a considerable share of the licensors in our sample has participated in more than one patent pool (and therefore patent held by these licensors are non-pooled to more than one pool) and our unit of analysis is patent, we selected the most relevant patent pool to each non-pooled patent based on the technological closeness of the pool to that patent (pools with higher share of patents with the same technological class of the non-pooled patent were chosen as the most relevant pool to each patent). The list of these pools along with the number of their non-pooled patent and the number of pool participants is presented in table A in Appendix.

**3.3 Descriptive statistics**

We start our discussion of the results with a set of descriptive statistics. The licensors in our entire sample of the patent pools are from 15 countries and are involved in several industries (totally 32 4-digit SIC codes). Morover, the patents in our sample of patent pools are from 96 patent offices all around the world. Table 1 presents general patent pool information concerning number of licensing packages, pool formation year, patent pool size, number of licensors , number of licensees , number of inpadoc families and number of tech classes (4 digit).

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Insert Table 1 about here

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In order to better understand the characteristics of the firms participating in the patent pools as well as the characteristics of the patents introduced to the patent pools, the descriptive analyses of patent pools in both firm and patent level is performed for the whole sample and for the sample of those patent pool licensors covered and not covered by PatVal II.

The average patent pool age in our sample is 12.13 the most recent patent pool in our sample is One Blue that was established in 2011, and the oldest pool is WirelessMesh formed in 1990. The oldest patent in our sample belongs to JVC KENWOOD Corporation and GE Technology Development Inc. that are members of MPGE4-Visual administrated by Mpegla. Patent pool formation has been more intensive in 2006 when 6 modern pools (25% of our sample) were formed and in 1997 when 5 modern pools (20% of our sample) were established. Furthermore, at least one patent pool has been established every year, duration the year 1997 to 2007. Moreover, after 1990 when Wireless Mesh was founded, no modern pool has been established until 1997 (a period of five years).

The average pool size in terms of the number of patents is 1083.54 in our sample of modern patent pools. Although One Blue is the youngest patent pool in our sample, it is the largest one in terms of the number of patents, comprising 10386 patents included in 22 licensing packages. On the other hand, ATSS administrated by Sisvel with 5 patents is the smallest patent pool in our sample. As it is shown in Table 1, particularly in consumer electronic industry, in standards such as (audio and video) compression and codec the numbers of licensees are considerably large (e.g. MPEG2, MPEG4 Visual and AVC pools) as the patent pools in this areas offer a wide technological coverage. On the other hand, in home systems, telecommunication and broadcasting technologies the pool's technological coverage is limited and therefore the numbers of licensees are much lower as compared to the CE patent pools. As depicted, a very large patent pool such as One Blue (home systems technology) has only 58 licensees. The number of licensees in ATSC, DVB-T, CATV and ARIB (broadcasting) and W-CDMA, IEEE 1394 and Wireless Mesh (telecommunication) are not also considerable.

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Insert Table 2 about here

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Out of the 70 patent pool members from the 86 pool licensing packages offered by 24 patent pools in our sample, 37 firms are covered by PatVal II. Table 2 shows the descriptive statistics of the general characteristics of entire sample of patent pools, patent pool licensors covered by PatVal II and patent pool licensors not covered by PatVal II and the result of the t-test of the equality of the means between them. We show that patent pool licensors covered by PatVal II have a higher average age and size as compared to patent pool licensors not covered by PatVal II. This is basically due to the presence of Nordic European countries which comprise the oldest firms in our sample of patent pool licensors covered by PatVal II. Moreover, patents held by patent pool licensors covered by PatVal II are more recent (higher priority year and publication earliest year) as compared to patent pool licensors not covered by PatVal II. However, as their patents are more recent they have received lower number of forward citations. "No. of inpadoc families/licensor" is measured as the total number of inpadoc families which belong to a licensor in the total sample. Likewise, No. of tech classes/licensor is calculated as the total number of technological classes which belong to a licensor in the total sample.
Table 3 illustrates the geographical distribution of the patent pool licensors in our sample. Europe has the highest average licensor age (92.88). As discussed, the oldest companies

participating in patent pools are from the Nordic European countries including Norway, Finland, Germany, and Sweden. The oldest licensor in our sample is SIEMENS (firm age = 168) and the youngest are DTVG LICENSING INC and JVC KENWOOD Corporation (firm age =7).

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Insert Table 3 about here

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The most active firms in terms of participating in the pools are from US (22 firms) and Japan(18 firms).Pool licensors covered by PatVal II are from Norway, Finland, Germany, Sweden, Canada and US. Moreover, the most active companies covered by PatVal II in terms of participating in pools are from Japan (12 firms) and US (8 firms).

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Insert Graph 1 and Graph 2 about here

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As depicted in Graph 1 and Graph 2 the highest share of the pool licensors covered by PatVal II are from Japan and US, respectively. Firms from these two countries comprise also the highest share of licensors not covered by PatVal II , however Japan has a lower share with respect to US. Moreover, while companies from Korea, China and Canada are not covered by PatVal II survey, PatValII does not also cover pool licensors from Italy although PatVal II surveyed Italian companies too. In fact, some companies within the pools were surveyed , but they are not in the list of respondent companies. Some of these licensors are large and others are smaller.

The frequency analysis of the 4-digit SIC codes in our sample shows that Household audio and video equipment (8.93%), Telephone and Telegraph apparatus (8.93%), Electronic components, not elsewhere specified (7.14%) and Telephone communications except for radio (7.14%) are the most common industries the patent pool members are involved in our sample of patent pools.

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Insert Table 4 about here

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Furthermore, with the aim of better understanding the technological area where a patent pool is specialized in, the Revealed Technological Advantage (RTA) for each patent pool is calculated on the basis of the formula adopted from Patel & Pavitt (1997). They argue that defining a large firm's technological competencies simply in terms of a few fields of excellence is misleading and it is better to think in terms of profiles of competencies with varying levels of commitment and competitive advantage in a range of technological fields. Based on the Patel & Pavitt (1997) approach, the distinctive core technical competencies are those with relatively high RTA and

Patent Share. Based on their approach in this study RTA is addressed as the relative importance of the firm to each field of technological competence, after taking account of the firm's total volume of competencies. Moreover, patent share is addressed as the relative importance of the firm’s competencies in each of the technological fields (30 fields). Based on their approach the Revealed Technological Advantage related to the Top OST for each pool is calculated as the share of the Top OST technological filed in the patent pool’s portfolio divided by the share of the Top OST technological filed in the entire portfolio of the 24 patent pools in our sample.

$$RTA_{ij} = \frac{\text{Share of i in patent portfolio j}}{\text{Share of i in the entire portfolio of the sample of the patent pools}}$$

Where   i = the Top OST technological filed in patent pool j

We calculate an Index for RTA as I = (RTA - 1) / (RTA + 1) , -1 < I < 1

Following their approach in calculating patent share we measure Technological Field Share (TFS) as the share of the pool’s top technological field (Top OST) in the entire sample of the patent pools. The higher the RTA and TFS the more important (central) is the technology for the patent pool. In other words the closer the RTA index to 1 the more important (central) is the technology for the patent pool. As depicted in Table 4, Audio-visual technology is the most dominant technological area covered by the patent pools in our sample (54.17% of the total sample). Moreover, Telecommunications (29.17% of the total sample) and Information Technology (16.67% of the total sample) are the other two technological areas covered by the patent pools in our sample. On the basis of Patel & Pavitt (1997) approach we find that Audio-visual technology is the core technology (I > 0.5) for *four* patent pools, including ATSC, ATSS, H.264 SVC and WSS. Telecommunication is the main technological area in *six* patent pools including W-CDMA, Wireless Mesh, ARIB, CATV, CATV Compliant and DVB-T2. Moreover, information technology is the core technological area in *four* patent pools including G.711.1, G.729.1, VC-1 and TOP Teletext. Audio-visual technology is not identified as the core technology for One Blue, DVD (6C), AVC, MPEG2, MPEG-4 Visual, MVC and DVB-T patent pools (I < 0.5). Surprisingly, RTA index is lowest for One Blue and DVD (6C) as the largest patent pools in consumer electronics industry.

Table 4 also depicts the firm-level and the patent-level descriptive analyses for each patent pool in our sample. The number of observations in the this table is associated to the total size of the database for each single patent pool in our sample. As shown, DVB-T has the highest average firm age (100) with minimum 6 and maximum 102 years. It has also the highest average firm size (no of employees) of 290235, with minimum 13299 and maximum 293742 employees. G.711.1 has the earliest average application priority year (2004) with the earliest patent applied in 2000 and the latest in 2007. The earliest average publication year (2006) is also associated to this patent pool, with the youngest paten published in 2001 and the oldest published in 2010. DVD-ROM (DRD) licensing package from DVD6C has the earliest average priority year (1976) among the 86 licensing packages in our sample with the earliest priority year of 1927 and the latest priority year of 2008. The average publication earliest year for this licensing package is 1980 with earliest publication year of 1929 and the latest of 2008.Moreover**,** G.711.1 has the highest average number of applicants (1.49) with the minimum of 0 and maximum of 12 applicants which is also the highest number of applicants associated to the patents in our patent pool sample.DVD-(+)RDisc administered by DVD6C has the highest average number of inventors (1.49) with the minimum of 0 and maximum of 12 applicants which is also the highest in our sample. This implies that on average the highest efforts have been dedicated to develop patents included in this patent pool in our sample. The patents from Wireless Mesh administrated by Mpegla have the highest average number of forward citations (159) among our sample of patent pools with the minimum citation of 6 and the maximum of 436, implying that companies participated in this pool are on average holding the highest quality pooled patents in our sample. Wireless Mesh has also the highest average number of publications claims (22) with a minimum of 0 and maximum of 64 publication claims implying that patents included in this pool have the highest avrage scope. Moreover, the patents from DVD-Video(DAP) licensing package administered by DVD6C have the highest number of publication claims (138) among the patents from our sample of patent pools.

Our data also shows that companies surveyed by PatVal II have participated in all the 24 patent pools licensing packages except for WirelessMesh, ATSS and TOP Teletext. The companies covered by PatVal II that have participated in G.729.1 have the highest average firm age (106) with the oldest firm aged 167 and the youngest aged 23, and those participated in G.711.1 have the lowest average firm age (21) with the oldest firm aged 26 and the youngest aged 17. The oldest company covered by PatVal II that has participated in the patent pools is SIEMENS (167-years) and the youngest is Thomson Licensing (15-years). The companies covered by PatVal II that have participated in DVB-T have the highest average firm size (291256 employees) with the largest firm size of 293742 and the lowest firm size of 118087 and those participated in MPEG-2 Systems have the lowest average firm size (8238 employees) with the maximum firm size of 110000 and the minimum firm size of 539. The companies covered by PatVal II that have participated in One Blue hold patents with lowest average priority earliest year (1988),with the earliest patents applied in 1925 and the latest patents applied in 2009. The highest average priority earliest year (2003) is associated to the patents held by the companies covered by PatVal II that have participated in G.711.1 with the earliest patents applied in 2000 and the latest patents applied in 2007. The lowest average priority earliest year in our sub-sample of the companies covered by PatVal II that have participated in patent pools is 1908 which is associated to the patents held by Panasonic Corporation in AVC and MPEG2 and the highest is 2011 which is associated to the patents held by Dolby Lab in MVC and VC-1.

Moreover, those companies covered by PatVal II that have participated in WSS hold patents with lowest average publication earliest year (1991), with the patents published in 1991 (Only one company: France Telecom). The highest average publication earliest year (2006) is associated to the patents held by the companies covered by PatVal II that have participated in G.711.1 with the oldest patents published in 2003 and the youngest patents published in 2010. The lowest average publication earliest year in our sub-sample of the companies covered by PatVal II that have participated in patent pools is 1909 which is associated to the patents held by Panasonic Corporation in AVC and MPEG2 and the highest is 2012 (associated to a number of licensors and pools in our subsample). Furthermore, those companies covered by PatVal II that have participated in ARIB hold patents with lowest average no of applicants (0.95), with minimum 0 (no applicant is recorded in EPO) and maximum 3 applicants. The highest average no of applicants (1.49) is associated to the patents held by the companies covered by PatVal II that have participated in G.711.1 minimum 1 and maximum 12 applicants. Those companies covered by PatVal II that have participated in WSS hold patents with lowest average no of inventors (1) (Only one company: France Telecom). The highest average no of inventors (6.75) is associated to the patents held by the companies covered by PatVal II that have participated in G.711.1 with minimum 0 and maximum 11 inventors. This implies that on average the highest efforts have been dedicated to develop patents included in this patent pool in our sample.Moreover,those the companies covered by PatVal II that have participated in WSS hold patents with lowest average no of forward citations (2) (Only one company: France Telecom). The highest average no of forward citations (117) is associated to the patents held by the companies covered by PatVal II that have participated in Mpeg 2- Systems with minimum 0 and maximum 224 citations, implying that the companies covered by PatVal II that have participated in this pool are on average holding the highest quality pooled patents in our sample.Finally, the companies covered by PatVal II that have participated in WSS hold patents with lowest average no of publication claims (0) (Only one company: France Telecom). The highest average no of publication claims (8.24) is associated to the patents held by the companies covered by PatVal II that have participated in W-CDMA with minimum 0 and maximum 80 publication claims. This implies that these companies are holding pooled patents with broadest average scope in our sample.

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Insert Graph 3 about here

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As it is depicted in Graph 3 more than 68% of the licensors have participated in more than one patent pool. Although these licensors are in general large and very large companies, there exist also some large firms that have not participated in more than one patent pool in our sample which might imply the fact that pool participation rate does not necessarily depend on the firm size as it might be expected and there might be several other factors that can explain pool participation rate. The largest rate of pool participation is fifteen for France Telecom and Panasonic Corporation and, thirteen for JVC KENWOOD Corporation, respectively. Sisvel SPA as a major pool administrator has participated as a licensor in one patent pool in our sample. This along with other data that we further explain in section 4 of this study regarding vertical integration to the pool technological standard implies that not necessarily all the pool members are manufacturing depending on the standard despite the fact that most of these companies in our sample are large or very large firms.

Furthermore, participation in more than one patent pool is particularly interesting when a firm that is mainly operating in one core technological area, is participating in patent pools contributing to different technologies. This might imply that a firm is seeking multimarket contacts or it is seeking strategic presence in some of these pools. Multimarket contact happens when companies come across the same competitors within various markets. Multimarket contact will help a company mitigate the risk of having aggressive competition in different markets with a competitor (mutual forbearance effect) (Edwards, 1955). Furthermore, in the market for IPR-based technologies a firm's bargaining power depends on the size of the firm's patent portfolio (Noel and Schankerman, 2006). In general firms with weaker bargaining power as compared to their competitors might acquire patents from others in order to strengthen their patent portfolio and increase their bargaining power. Nevertheless, firms might pursue another strategy as patent acquisition is not always a long term and less costly solution if a company is competing in various markets with others. Indeed, firms are at a higher risk of having less bargaining power in some technological areas which is not in their core business as compared to their competitors that are operating mainly in those technological areas. Therefore, they might take advantage of the pool's membership in an attempt to moderate the effect of other's bargaining power in those technological fields. In other words multiple pool membership provides a firm with access to other competitors' technology with a lower bargaining and contracting cost (lower transaction cost). Hence, in general apart from seeking broader technological capacities and rent earning advantages, it can be argued that firms participating in multiple pools might have higher strategic intentions in dealing with their competitors.

## 4. Measurements, data analysis and regression results

### 4.1 Measurement

#### 4.1.1. Dependent variable

Our dependent variable in this study is the willingness to use non-pooled(unused) patent which is a dummy equal to 1 if a (non-pooled) patent is not used ( in either of the 4 ways including internal commercialization, licensing, sale and spin off ) but its owner is willing to use it and 0 otherwise. PatVal II askes among other things if the applicant(s) or affiliated parties ever used the patented invention commercially or if the ownership right to the patent was sold or licensed to another party not related to the original owner(s) or applicant(s), or if this patent been used by any of the inventors or applicants to found a new company. It also askes whether the owner is willing to use the patent in case the patent is not used in either of these ways. Descriptive statistics show that 40.62% of the patents in our working sample (528 observations) are not used but their owner is willing to use them.

#### 4.1.2. Explanatory variables

Our explanatory variables include participation intensity and technological complementarity

#### *4.1.3. Participation intensity:*

Participation intensity in our study refers to the number of patents a licensor has included in each pool out of its patent portfolio. In fact, the share of a licensor's patent stock that is included in a patent pool shows how intensively it has contributed to the pool. Since the contribution to the pool in this sense is related to the portion out of the firm's patent portfolio (patent stock) that is incorporated into the pool, we operationalized participation intensity in patent pools as the number of patents included in a patent pool by a licensor divided by its patent stock. The intensity of participation is therefore different from the firm's bargaining power within the pool, which is in fact the share of a licensor's patents out of the patent pool's patent portfolio (total patents within the pool). We further control for firm's bargaining power within the pool in our analysis as it is discussed in the next section.

***4.1.4. Technological complementarity***: Makri, Hitt, and Lane (2010) define Technology Complementarity between firms as “the degree to which their technological problem solving focuses on different narrowly defined areas of knowledge within a broadly defined area of knowledge that they share”. In their approach technology complementarity is operationalized as the overlap in patents in the same subcategory (field) but in a different class. This definition implies technology complementarity within a value chain activity versus asset complementarity across different value chain activities. According to them a broader definition of complementarity from an economic perspective by Milgrom and Roberts (1990; 1995) is also supported by this definition in which marginal return from an input increases as it is combined with another impute.

Adapting the same approach and using the same level of aggregation we operationalize technological complementarity between a firm’s patents and a patent pool as the overlap in patents in the same technological field (30 OST) but in a different patent class (3-digit-IPC) weighted by the importance of each patent tech field in each pool.

$$\left(\frac{\text{Overlap All Patent Tech fields}}{\text{Total patent pool and firm patent}} - \frac{\text{Overlap all Patent classes}}{\text{Total Patents Pool and firm patent}}\right) \times$$
$$\left(\frac{\text{Total patent pool patents in common Tech field}}{\text{Total patent pool patents}}\right)$$

For instance, two patents build on technological field ‘Telecommunications’ (3) but on different class ‘Digital information transmission’ (H04L) and ‘Telephone communication’ (H04M), occupy complementarity technologies. This measure is validated in the context of M&A by Makri, Hitt, and Lane (2010) using a 1996 sample of 95 high-technology M&As. They collected data from trade magazines on the acquiring and acquired firms’ research content for 24 deals in the electronics industry and for 24 deals in the drug industry (n = 48). They asked two highly qualified professionals (unrelated to their study) to carefully read through all of the information provided for each firm and to rate the knowledge complementarity present between the two firms in each deal. They rated the complementarity between the two firms on a five-point Likert scale. Then they calculated the correlations between their ratings on knowledge complementarity and their objective measures of technology complementarity. They found a positive and statistically significant correlation between their objective measure of technology complementarity and the raters’ evaluation of knowledge complementarity. These results provided support for the construct validity of their measure of technology complementarity.

### 4.1.5. Control Variables

We control for various patent pool, firm, and technological level factors in our analyses which are examined in the literature. Our patent pool-level control variables include patent pool age and patent pool size. Patent pool age is calculated at the time of this survey (2011) on the basis of the formation year of the patent pool in years. Patent pool's state of technology is captured by pool age. The higher the age of the patent pool the lower the probability that pool attracts new members as the technology covered by the pool becomes more obsolete and therefore the companies might have less willingness to find a way to use their patents through participating in these pools. At pool level we also control for patent pool size. Pool size is measured as the total number of patents included in a pool by the licensors. Firm-level control variables include licensor size, licensor age, licensor's pooling experience and membership duration. We control for the size of the licensor by using 6 dummy variables. Through these dummies we distinguish the size by number of employees from the baseline category of small firms employing 1 to 100 workers (representing 1 % of the observations in our sample) to very large firms employing more than 5000 workers(representing 81.3% of the observations in our sample). We also control for Licensor age measured at the time of the survey in years. Pooling experience is measured as the number of pools each licensor has participated in. As argued companies with higher pooling experience (participated in more pools) might have higher strategic intentions in dealing with their competitors which might affect their willingness to use their non-pooled patents through participating in pools composed of higher number of their competitors. We also control for the firm's bargaining power within the pool. In principle, firms that own more patents within the pool as compared to other members have a higher contribution to the technological development of the pool and therefore attain more bargaining power within the pool. In fact, firms bargaining power within the pool motivates it to take more advantage of the pool in order to commercialize its patents. Moreover, having more patents within the pool as compared to other members might also imply that the licensor has higher presence in the technological area of the pool and as a result might have more willingness to use its non-pooled patents through pool participation too since these patents are more likely to be related to the pool's technology. We also control for membership duration. The longer a firm has been participated in a pool, the more likely it is to use its patents through pool participation because it is more familiar with the pools' technology, which helps it to figure out better ways to use its non-pooled patents through having access to the pool's technology. Longer membership duration also increases the familiarity of the firm with other members and licensees and therefore increases the likelihood for collaboration opportunity outside the pool with them. Moreover, the longer a firm has participated in a pool, the more it could learn novel and more efficient ways of commercializing its patents through pool membership opportunity. Our first patent-level control variable is the number of inventors for each patent which provide us with a measure of the efforts that have been dedicated to accomplish an invention. The higher the number of inventors for each patent the higher might be the willingness to use an invention as more efforts has been dedicated to develop it. At the patent level, we also control for the priority date (year) of patents for 2003-2004-2005.

### 4.2 Empirical Framework

Table 5 shows the list of variables used in our analyses along with their descriptions and sources. The descriptive statistics for these variables and their correlation matrix are also presented in Table 6 and Table 7.

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Insert Table 5 Table 6 and Table 7 about here

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### 4.3 Regression results and discussion

Before carrying the econometrics analysis of our study we checked for the existence of multicollinearity among the explanatory variables which is considered as one of the most typical econometrics issues with cross-sectional regressions. In the correlation matrix of the covariates, Pearson correlation coefficients were all < 0.5 except for some values for number of inventors, patent pool age and patent pool size. We further investigated the issue computing variance inflation factor. We found that VIF is less than 2.5 for all our variables. Moreover, the average variance inflation factor for our model is 1.49.

Since our dependent variable willingness to use non-pooled patents is dichotomous we employ probit estimator in our regression analysis (Greene, 2000). The results of the probit estimation are shown in Table 8. We first ran the control model including patent, firm and patent pool level factors. The first column of the table shows the average marginal effects calculated for the direct effect model including our main dependent variable and our two explanatory variables. In the second column we show the results of our probit estimation for our control model. We progressively add our regressors including participation intensity and technological complementarity to the control model through column 3 and 4. As it is shown this did not really impact the significance and magnitude of each variable. Therefore, we interpreted the results from our last model (column 4).

Hypothesis 1 is regarding the link between the level of technological complementarity between firm and patent pool and willingness to use non-pooled patents. Technological complementarity is positive and significant increasing the likelihood of willingness to use non-pooled patents by

66.8% and as a result Hypothesis 1 is supported by our results. This significant magnitude shows that while a company might contribute to development of a pool's technology, it considers patent pool as an important complementary technology supplier. Since 81.30 % of the licensors in our smaple are very large companies our results further imply that, albite such companies broadly operate in one or more technological fileds they still seek less costly and easier access to complementary technologies provided by other companies and even by their rivals.

Hypothesis 2 is concerning the link between pool participation intensity and willingness to use non-pooled patents. The results from our final model shows that pool members participating intensively in patent pools are more likely to hold non-pooled patents that they are willing to use through pool participation as participation intensity is positive and significant. The magnitude of the link between participation intensity and the willingness to use non-pooled patents is considerable while we have controlled for patent, firm and patent pool observable factors. Participation intensity in patent pools increases probability of willingness to use non-pooled patents by 18.9%. Hence our results support hypothesis 2. Again, since very large licensors comprise a considerable share of our sample these results further suggest that as the most active companies in patent pools they are also more willing to use their non-pooled patents through pool participation as they also contribute more intensively to the technology development of the pool's standard.

We controlled for patent, firm and patent pool level variables. As expected membership duration is positive and singinicant (about 7%) while its magnitude remains almost unchanged after we progressively add explanatory variables to our model. Licensors involved in pools for a longer duration have in principle higher willingness to use their patents as they have gain higher inforamtion and knowledge from the pool, while being involved in technology development of the pool. They have also higher collaboation opportunities with other members and licensees out of the pool as they have been longer connected to them through the pool. Pooling experience while positive is also not significant. Patent pool size is positive and significant however its magnitude is zero. Furthermore, patent pool age while negative is not significant.

While positive all size dummies are also not significant compared to baseline licensor size category (1-99 licensors) except for medium (100-299) size dummy that is negative and significant at 10% level. Nonetheless, medium size licensors comprise only 1% of our sample and therefore it could be argued that the effect of the licensor size is negligible. Moreover, while the magnitide of licensor age is almost zero it is not significant. Number of inventors is negative and significant however its magnitude is not really considerable(1%) too. Comparing to our baseline category for priority date (2003), only priority date 2004 is positive and significant ($P < 0.05$) and its magnitude remains unchanged while progressively adding the explanatory variables. This implies that licensors are more likely to be willing to use those non-pooled patents which were filed in 2004, through pool participation.

An important issue addressed in this study is the issue of self-selection bias as the companies are self-selected to the sample of pool licensors since they decide whether or not to participate in a pool. Since participation intensity is used as our explanatory variable for willingness to use non-pooled patents, being a choice variable (self –selection) causes endogeneity issue. To test the endogeneity of participation intensity we used Durbin Wu Hausman and Wald test of endogeneity. We found that our hypothesis of exogeneity is rejected and participation intensity is endogenous at 10 percent level. The results of these tests are reported in table 9. Furthermore, in order to address the endogeneity issue we use instrumental variables approach. Since our endogenous variable is continues we use IVProbit model to address the issue (Neway, 1987). Relying on the literature on patent pools we employ vertical integration (dummy) as our instrumental variable that explains pool participation. According to Layne-Farrar and Lerner (2011), vertically integrated firms with patents and downstream operations (companies conducting relevant R&D and manufactures a product dependent on the standard) are more likely to join patent pools. In order to construct the variables vertically integrated (to the standard) the relevant information on product and services is collected for each licensor to identify if that licensor is involved also in manufacturing any products based on the standard associated to the pool it has participated in. This included searching the licensor's web-site, 10-k and finally keyword searching in search engines to double check the results. The non-vertical integrated licensors include those which do not manufacture any product relying on the standard associated to the pool. Our instrument vertically integrated is correlated with pool participation intensity ($r = 0.205$, $p< 0.001$) and uncorrelated with willingness to use non-pooled patents.

In employing the instrumental variable method, the effectiveness of the procedure depends on the instruments' validity. The validity of vertical integration as the instrumental variable is examined by weak instruments test using the first stage regression summary statistics. Our partial test statistics ($F = 61.24$ and $p < 0.000$) proves that we don't have weak instrument variable problem. According to Stock and Staiger (1997) the endogeneity tests can be misrepresentative if we have weak instruments. Indeed, in case of employing a weak instrument the presence of other control variables will bring about an artificially high correlation between the instrument and the endogenous variable. Staiger and Stock (1997) propose evaluation of the partial correlation of the endogenous variable and the instruments as a test for weak instrument. According to their test a partial F-statistics value higher than 10 ensures that our instrument is not weak. We also used Finlay and Magnusson (2013) test for weak instrument to further check the robustness of our instrumental approach[13]. They developed a series of inference tests including the Anderson - Rubin (AR) that is robust to weak instruments for the IV Tobit/Probit model in Stata. The Anderson and Rubin (1949) test determine the significance of the null hypothesis that the coefficients of the endogenous regressor in the equation is equal to zero. As shown the confidence set from the Wald test is very close to those from AR, which indicates that our instrumental variables is not weak.The result of this test is shown in table 10.

While results reveal the consistency of our probit model, our IVProbit model demonstrates how the relationships between our main regressors and willingness to use non-pooled patents hold after controlling for the potential endogeneity of participation intensity. In other words, while the average marginal effects resulted from the instrumental variable estimation are still positive and significant for all our three regressors the coefficient for participation intensity using instrumental approach is significantly bigger than the coefficient from probit approach with higher significance level, suggesting that endogeniety is not a major problem.

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Table 9 and Table 10 about here

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In order to further check the robustness of our results we also tested our hypothesis by running linear probability model. The results are consistent with our finding through probit estimation. To account for the endogeniety issue, we also used instrumental variables approach employing 2SLS model. While results reveal the consistency of the LPM model, two-stage least squares model demonstrates how the relationships between our main regressors and willingness to use non-pooled patents hold after controlling for the potential endogeneity of participation intensity. In other words, while the coefficients resulted from the instrumental variable (2SLS) regression, are still positive and significant for both regressors with almost the same significance level as that of the LPM model, the coefficient for participation intensity using instrumental approach is significantly bigger than the coefficient from LPM approach, suggesting that endogeniety is not a major problem. The resuls of these estimations are presented in Tabel 11.

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Table 11 about here

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[13] We use weakiv (Finlay et al., 2013) commands in STATA, available at: http://ideas.repec.org/c/boc/bocode/s457684.html (weakiv)

## 5 Implications and conclusion

The emergence of patent pools as policy tools facilitating technology commercialization and alleviating patent litigations among rivals holding overlapping IPRs has caught management scholars and policy makers' attention. Looking at the role of patent pools in the market for technology from this lens, in this study we focused on extending the empirical literature on patent pools and patent nonuse. In light of the existence of considerable number of unused patents held by pool members out of the patent pool, and different mechanisms that patent pools offer which might favor the use of patents, the main focus of our study has been on the association between participation in patent pools and firm's willingness to use their non-pooled patents through pool participation. We provide novel findings on how the benefits associated to pool membership can go beyond the pooled patents. In fact, the convergence between strategic patenting (and patent nonuse) literature and patent pool studies identifying the benefits related to patent pools does not exceed some theoretical papers concerning the role of patent pools in decreasing the transaction cost associated to licensing of blocking patents (Carlson, 1999; Shapiro, 2001 ; Merges, 1999), providing equal access of all the pool members to these patents (Sung and Pelto, 1998) and very few empirical studies concerning the role of pools in decreasing the rate of strategic patenting in the market for technology (Lampe and Moser, 2014). Therefore, there exists particularly a lack of empirical analysis on the relationship between pool participation and facilitation of patent use perceived by companies. We cover this gap, extending the theory on the patent commercialization benefits associated to pool participation perceived by firms involved in the market for technological standards to the commercialization of their non-pooled patents. Starting with the theoretical literature, two hypotheses were developed that were tested using a sample of pool participants from PatVal II Survay data that have joined patent pools in telecommunication and consumer electronics industry between 2003 and 2011. We show that pool licensors are more likely to be willing to use their non-pooled patents by participating in patent pools with higher level of technological complementarity to their own technology. We also show that pool members participating more intensively in patent pools are more likely to be willing to use their non-pooled patents through pool participation. The two hypotheses we developed were supported by our econometrics analysis. In our final probit model, the strongest support was for H2 that predicted pool licensors are more likely to be willing to use their non-pooled patents through participating in patent pools with higher level of technological complementarity to their own technology.

In fact, pools provide different level mechanisms, which are seen by companies as means for facilitating their technology commercialization. Particularly, pool members facing challenges with licensing out or selling their non-pooled patents or those holding unused patents within technology markets where brokers and intermediaries are not efficiently connecting licensees and licensors see participation in patent pools an opportunity in order to commercialize their patents. This is due to the fact that first, providing technologies, which are complementary to the firm's technology is a beneficial patent (technology) level mechanism provided by the patent pools to its licensors that can help the licensor exploit its non-pooled patents. In fact, by getting access to the technologies provided by other members within the pool, the company can exploit its technological resources, which have not been involved in the pool. Perceiving, such benefits affects a licensor's willingness to use its non-pooled patents through participating in patent pools. Second, increased information and knowledge spillover and higher collaboration opportunities are other beneficial mechanisms offered by patent pools at the firm level, which affects the willingness of a pool member to use their non-pooled patents through participating more intensively in pools. Moreover, providing access to broader technology implementers within the market is another mechanism offered by patent pools at market level which increases the likelihood of willingness to use non-pooled patents through more intensive participation in pools.

This study contributes to the current discussion on social, economic and technological benefits of patent pools. We argue that companies involved in highly fragmented IP markets that have the possibility to adopt a more progressive IP exploitation approach and use their patents beyond just protecting their products and services by contributing them to patent pools, do not only see participation in patent pools as an opportunity to facilitate their patent (technology) commercialization by introducing their patents to the pool since in the absence of a pool they can't use their technology without infringing on their competitors' patents. They also see pool participation as a way to facilitate the use of their unused patents which have not been included in the pool due to different reasons.

Moreover, in order to contribute to the better understanding of how pool participation explains the willingness to use non-pooled patents we investigated if pool's level of technology complementary to a licensor's technology as a pool characteristic is associated to the willingness to use these patents through participating in patent pools.

## 5.1. Study limitations and future research

Our research is limited by the unavailability of further data on use of patents. We can only observe use/nonuse of the patent and the willingness to use of its owner. We cannot observe the time of use of the patent to further investigate to what extent patent pools can affect the rate of use of non-pooled patents. Future research might use a more detailed database to investigate this effect.

Moreover, the relevance of our findings might be limited to the patent pools involved in industries with complex technologies as the results of our study is based on the data from the patent pools in ICT sector. Our data shows the number of patent pools in complex industries have been growing during the last two decades while the number of patent pools formed in discrete technologies has been considerably lower. Moreover, the significance of patent pools in the context of standard technology developments is more within complex technologies were access to complementary standard essential patents is important for commercializing a firm's patent. As a result, we believe our findings cannot be generalized to discrete industries due to the difference between market and technology drivers and mechanisms within these two types of industries.

## 5.2. Policy implications

The results of this study have practical implications for strategic decision-makers and for companies and policy makers dealing with the issue of patent nonuse, overlapping IPRs and cumulative innovations. In particular, this study highlights the role and importance of patent pools perceived by companies involved in in highly fragmented IP markets in facilitating the commercialization of their technology, for scholars, policy makers and practitioners. Moreover, it is important for policy makers to understand in which areas the key enabling technologies provided by patent pools are more relevant and advantageous to the companies as technology transfer and exploitation tools. Accordingly, policy makers might also dedicate efforts to find out sectors in which there is a clear lack of patent pools.

This study also suggests alternative solutions to compulsory licensing purposed by policy makers as a legislative way to facilitate the external commercialization of patents that is not considered as a favorable solution in many countries. In fact, while enforcement of some IP laws cannot be always efficient and socially acceptable, encouraging companies to contribute to aggregation mechanisms such as patent pools would be less costly and more expedient. Our study also suggest that rather than acquiring complementary patent portfolios which apart from being costly and more risky is not always a long term solution particularly if the company is competing in various markets, a firm seeking complementary technologies could consider joining patent pools which provide a broader and more efficient access to these technologies. Government bodies should therefore consider policies which can foster the formation and optimal functioning of patent pools. Moreover, they should consider policies that encourage and facilitates the process of IP aggregation or encourage participating in them.

Furthermore, as discussed large and very large firms comprise the highest share of the companies participating in patent pool. This might show that large firms as compared to SMEs have a higher opportunity to join pools and therefore have a greater chance to get their technology commercialized. This fact should be considered by policy makers in order to design policies that could help SMEs with key technologies to overcome entry barriers to the pools and consequently advance their technology commercialization through pool membership.

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## Table 1- Summary of patent pools’ information

| Patent pool | No of licensing Packages | Pool Formation year | Patent pool size (no. of patents) | Number of licensors | Number of Licensees | No. of inpadoc families | No. of Tech Classes(4 digit) |
|---|---|---|---|---|---|---|---|
| **One Blue** | 22 | 2011 | 10386 | 15 | 58 | 3293 | 470 |
| **3G-G.711.1** | 1 | 2006 | 30 | 5 | 5 | 10 | 6 |
| **3G-G.729.1** | 1 | 2006 | 56 | 9 | 5 | 27 | 21 |
| **3G-W-CDMA** | 1 | 2004 | 649 | 12 | 10 | 438 | 85 |
| **DVD (6C)** | 42 | 1998 | 5046 | 9 | 106 | 2802 | 407 |
| **Mpegla-ATSC** | 1 | 1996 | 246 | 9 | 130 | 68 | 26 |
| **Mpegla-AVC** | 1 | 2002 | 1042 | 27 | 1177 | 286 | 116 |
| **Mpegla-IEEE 1394** | 1 | 1999 | 271 | 10 | 226 | 178 | 93 |
| **Mpegla-MPEG2** | 1 | 1997 | 1041 | 27 | 1432 | 281 | 115 |
| **Mpegla-MPEG-2 Systems** | 1 | 2001 | 237 | 11 | 206 | 66 | 46 |
| **Mpegla-MPEG-4 Systems** | 1 | 2003 | 66 | 7 | 41 | 38 | 31 |
| **Mpegla-MPEG-4 Visual** | 1 | 2003 | 1248 | 29 | 701 | 458 | 194 |
| **Mpegla-MVC** | 1 | 2002 | 2940 | 27 | 19 | 679 | 232 |
| **Mpegla-VC-1** | 1 | 2006 | 787 | 18 | 287 | 202 | 78 |
| **Mpegla-Wireless Mesh** | 1 | 1990 | 41 | 2 | 41 | 11 | 17 |
| **Uldage-ARIB** | 1 | 2006 | 511 | 13 | 283 | 404 | 123 |
| **Uldage-CATV** | 1 | 2006 | 342 | 15 | 8 | 256 | 81 |
| **Uldage-CATV Compliant** | 1 | 2006 | 468 | 15 | 8 | 353 | 103 |
| **Sisvel-ATSS** | 1 | 1997 | 5 | 2 | 20 | 2 | 1 |
| **Sisvel-DVB-T** | 1 | 2004 | 386 | 4 | 476 | 92 | 88 |
| **Sisvel-DVB-T2** | 1 | 2008 | 122 | 7 | 448 | 37 | 46 |
| **Sisvel-H.264 SVC** | 1 | 2007 | 61 | 3 | 1321 | 13 | 5 |
| **Sisvel-TOP Teletext** | 1 | 1997 | 13 | 2 | 64 | 8 | 3 |
| **Sisvel-WSS** | 1 | 1997 | 11 | 5 | 20 | 4 | 2 |
| **Total** | 86 | n/a 12.1 | 21476 | 7 | 7092 | 7582 | 2389 |
| **Mean** | | 4.72 | 1083.54 | 11.62 | 487.5 | 416.91 | 487.5 |
| **STD** | | | 25182.3 | 8.12 | 884.64 | 833.90 | 884.64 |

### Table 2- Descriptive statistics of the general characteristics of entire sample of patent pools, Patent pool licensor covered by PatVal II and Patent pool licensor not covered by PatVal II

| | Full sample | | | Patent pool licensor covered by PatVal II | | | Patent pool licensor not covered by PatVal II | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **No. of Obs.** | **Mean** | **STD** | **No. of Obs.** | **Mean** | **STD** | **No. of Obs.** | **Mean** | **STD** | **P value** |
| | ***Firm-Level Characteristics*** | | | | | | | | | |
| Licensor age | 70 | 64.86 | 44.56 | 37 | 79.61 | 43.01 | 33 | 47.42 | 40.37 | 0.001 |
| Licensor size | 70 | 72703 | 91621 | 37 | 90906 | 95232 | 33 | 48223 | 81831 | 0.081 |
| | ***Patent-Level Characteristics*** | | | | | | | | | |
| Priority earliest year | 21476 | 1990 | 16.41 | 164121 | 1990 | 16.35 | 18407 | 1988 | 16.72 | 0.000 |
| Publication earliest year | 21476 | 1995 | 17.30 | 164333 | 1995 | 17.26 | 18411 | 1992 | 17.40 | 0.000 |
| No. of applicants | 21476 | .99 | .37 | 164546 | .99 | .37 | 18417 | .97 | .31 | 0.000 |
| No. of inventors | 21476 | 2.44 | 2.09 | 164546 | 2.49 | 2.16 | 18417 | 2.02 | 1.25 | 0.000 |
| No. of forward citations | 21476 | 27.44 | 36.13 | 164546 | 27.32 | 35.51 | 18417 | 28.51 | 41.21 | 0.000 |
| No. of publication claims | 21476 | 4.62 | 10.41 | 164546 | 4.74 | 10.50 | 18417 | 3.57 | 9.57 | 0.000 |
| No. of Inpadoc families/licensor | 21476 | 1000 | 744.46 | 164454 | 1076 | 742.7 | 17893 | 306.24 | 207.45 | 0.000 |
| No. of tech classes/licensor | 21476 | 1427 | 1122 | 163644 | 1526 | 1134 | 17893 | 519.23 | 315.18 | 0.000 |

### Table 3: Geographical distribution of patent pool licensors

| Country | Licensor age average |
|---|---|
| Norway | 159 |
| Finland | 149 |
| Sweden | 138 |
| Denmark | 99 |
| Netherlands | 68.33 |
| United Kingdom | 62.5 |
| France | 44.25 |
| Italy | 23 |
| **Europe** | **92.88** |
| United States | 45.8182 |
| Canada | 15 |
| **North America** | **30.40** |
| **Japan** | **82.38** |
| Korea | 54.2 |
| China | 43.5 |
| Taiwan | 18 |
| **Asian countries excluding Japan** | **34.67** |

## Table 4 -Patent pool-level descriptive statistics – Pool licensors covered by PatValII

| Patent pool | | Licensor age | Licensor size | Priority earliest year | Publication earliest year | No. of applicants | No. of inventors | No. of citations | No. of publication claims | Top SIC Code | Top ISI-0ST-INPI Area | I = (RTA -1)/ (RTA+1) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **One Blue (N= 10386)** | **Mean** | 91.55 | 154058.6 | 1988 | 1992.24 | .96 | 2.40 | 17.50 | 4.13 | Audio-visual technology | 365 | 0.02 |
| | **STD** | 18.55 | 120960.5 | 18.55 | 19.60 | .45 | 2.27 | 27.55 | 10.93 | | | |
| **3G-G.711.1 (N=30)** | **Mean** | 21.5 | 154347 | 2003.5 | 2006.4 | 1.45 | 6.75 | 13.20 | 6.16 | Information technology | 481 | 0.84 |
| | **STD** | 4.54 | 14498.82 | 3.51 | 3.01 | 2.22 | 4.36 | 9.67 | 7.92 | | | |
| **3G-G.729.1 (N=56)** | **Mean** | 106.6 | 173942.8 | 1995.34 | 1998.46 | 1 | 1.67 | 15.26 | 3.39 | Information technology | 481 | 0.67 |
| | **STD** | 65.33 | 44122.95 | 3.87 | 4.29 | 0 | 1.18 | 10.93 | 5.42 | | | |
| **3G-W-CDMA (N=649)** | **Mean** | 88.30 | 221582.9 | 1996.61 | 2002.67 | .99 | 2.34 | 40.03 | 8.24 | Telecommunications | 481 | 0.73 |
| | **STD** | 38.99 | 89786.74 | 4.61 | 3.73 | .14 | 2.37 | 25.00 | 9.92 | | | |
| **DVD (6C) (N=5046)** | **Mean** | 91.75 | 221912.5 | 1989.42 | 1993.22 | 1.03 | 2.99 | 34.70 | 5.32 | Audio-visual technology | 363 | 0.12 |
| | **STD** | 12.00 | 69147.62 | 18.90 | 18.99 | .38 | 2.29 | 44.85 | 10.99 | | | |
| **Mpegla-ATSC (N=1478)** | **Mean** | 98.90 | 188843.7 | 1994.88 | 1999.214 | .98 | 1.21 | 29.37 | 5.78 | Audio-visual technology | 365 | 0.57 |
| | **STD** | 16.93 | 105896.4 | 5.21 | 6.71 | .20 | .56 | 26.67 | 9.28 | | | |
| **Mpegla-AVC (N= 246)** | **Mean** | 74.90 | 88940.16 | 1989.60 | 1996.21 | .96 | 2.12 | 63.03 | 3.86 | Audio-visual technology | 365 | 0.38 |
| | **STD** | 37.74 | 98864.79 | 10.63 | 12.60 | .24 | 1.49 | 56.72 | 8.21 | | | |
| **Mpegla-IEEE 1394 N=(1042)** | **Mean** | 79.21 | 131921.6 | 1992.37 | 1998.9 | .986 | 3.02 | 46.61 | 5.16 | Telecommunications | 365 | 0.34 |
| | **STD** | 31.03 | 111118.6 | 8.70 | 10.18 | .204 | 1.57 | 45.67 | 8.39 | | | |
| **Mpegla-MPEG2 (N=271)** | **Mean** | 71.68 | 70037 | 1989.57 | 1995.96 | .971 | 2.19 | 60.92 | 3.72 | Audio-visual technology | 365 | 0.31 |
| | **STD** | 40.71 | 82601.28 | 9.50 | 11.47 | .360 | 1.59 | 54.22 | 9.08 | | | |
| **Mpegla-MPEG-2 Systems (N=1041)** | **Mean** | 26.06 | 8238.70 | 1992.26 | 1999.02 | 1 | 1.55 | 117.56 | 2.25 | Audio-visual technology | 366 | 0.35 |
| | **STD** | 31.05 | 24199.53 | 3.12 | 6.25 | .07 | .77 | 87.69 | 4.74 | | | |
| **Mpegla-MPEG-4 Systems (N=237)** | **Mean** | 72.20 | 165925.3 | 1992.99 | 1997.199 | 1.09 | 2.03 | 40.43 | 2.004 | Audio-visual technology | 369 | 0.36 |
| | **STD** | 36.08 | 96549.21 | 9.304 | 9.71 | .37 | 1.11 | 36.98 | 6.10 | | | |
| **Mpegla-MPEG-4 Visual (N=66)** | **Mean** | 97.91 | 181960.2 | 1991.84 | 1997.69 | .971 | 2.53 | 39.95 | 3.81 | Audio-visual technology | 363 | 0.18 |
| | **STD** | 18.12 | 106873.9 | 12.52 | 14.10 | .220 | 1.75 | 40.78 | 9.92 | | | |
| **Mpegla-MVC (N=1248)** | **Mean** | 100.56 | 138651.8 | 1999.92 | 2005.48 | 1.00 | 2.50 | 21.20 | 5.29 | Audio-visual technology | 363 | 0.17 |
| | **STD** | 26.87 | 26.87 | 26.87 | 26.87 | 26.87 | 26.87 | 26.87 | 26.87 | | | |
| **Mpegla-VC-1 (N= 41)** | **Mean** | 74.33 | 90306.32 | 1996.57 | 2001.96 | 1.01 | 2.39 | 32.94 | 7.61 | Information technology | 737 | 0.91 |
| | **STD** | 33.19 | 33.19 | 33.19 | 33.19 | 33.19 | 33.19 | 33.19 | 33.19 | | | |
| **Mpegla-Wireless Mesh (N= 0)** | **Mean** | - | - | - | - | - | - | - | - | Telecommunications | | 0.78 |
| | **STD** | - | - | - | - | - | - | - | - | | | |
| **Uldage-ARIB (N=1210)** | **Mean** | 84.98 | 170883.1 | 1994.28 | 1999.39 | .957 | 2.216 | 17.53 | .001 | Telecommunications | 367 | 0.58 |
| | **STD** | 15.35 | 66578.85 | 4.873 | 5.4445 | .337 | 2.23 | 27.95 | .057 | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Uldage-CATV (N=342)** | **Mean** | 93.01 | 191662.4 | 1991.35 | 2001.66 | 1.011 | 1.041 | 44.44 | 2.58 | Telecommunications | 357 | 0.69 |
| | **STD** | 23.37 | 111649.8 | 4.64 | 6.34 | .116 | .4041 | 16.45 | 4.25 | | | |
| **Uldage-CATV Compliant (N=468)** | **Mean** | 92.20 | 174384.8 | 1994.451 | 1999.98 | 1.03 | 2.37 | 26.15 | .0053 | Telecommunications | [illegible] | 0.65 |
| | **STD** | 24.93 | 114481.1 | 4.75 | 5.187 | .29 | 2.06 | 40.06 | .163 | | | |
| **Sisvel-ATSS (N=0)** | **Mean** | - | - | - | - | - | - | - | - | Audio-visual technology | 749 | 0.87 |
| | **STD** | - | - | - | - | - | - | - | - | | | |
| **Sisvel-DVB T (N=386)** | **Mean** | 100.6 | 291256.1 | 1991.35 | 2001.66 | 1.011 | 1.041 | 44.44 | 2.58 | Audio-visual technology | 363 | 0.12 |
| | **STD** | 10.36 | 18058.23 | 4.64 | 6.34 | .116 | .4041 | 16.45 | 4.25 | | | |
| **Sisvel-DVB T2 (N=122)** | **Mean** | 93.98 | 68107.52 | 1996.64 | 1999.91 | 1.07 | 1.77 | 11.77 | 3.25 | Telecommunications | 365 | 0.65 |
| | **STD** | 19.85 | 41294.91 | 12.99 | 13.45 | .332 | 1.45 | 21.94 | 5.745 | | | |
| **Sisvel-H.264 SVC (N= 61)** | **Mean** | 25.21 | 128878.2 | 1993.37 | 1998.27 | 1.02 | 2.75 | 13.49 | 4.02 | Audio-visual technology | 489 | 0.78 |
| | **STD** | .411 | 20804.88 | 9.97 | 10.16 | .147 | .83 | 13.55 | 6.51 | | | |
| **Sisvel-TOP Teletext (N=0)** | **Mean** | - | - | - | - | - | - | - | - | Information technology | | 0.84 |
| | **STD** | - | - | - | - | - | - | - | - | | | |
| **Sisvel-WSS (N= 11)** | **Mean** | 26 | 168694 | 1990 | 1991 | 1 | 1 | 2 | 0 | Audio-visual technology | 599 | 0.92 |
| | **STD** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |

## Table 5- Variables used in this study

| Variable | Description | Source |
|---|---|---|
| **Unused-willing to use** | *Dummy*-The patent is not use in either of the 4 ways (internal commercialization, licensing(and cross licensing), sale, spin off) but its owner is willing to use it | PatVal II |
| **Participation intensity** | Number of patents firm has included in a pool divided by its patent stock | EPO Patstat |
| **Technological complementarity** | overlap in patents in the same subcategory but in a different class (Makri, et al) | EPO Patstat, UC Berkeley Fung database & Patent pool websites |
| **Priority year** | *Dummy*-The year in which the invention was filed to EPO | EPO Patstat |
| **No. of inventors** | *Dummy*- The number of inventors for each patent | EPO Patstat |
| **Licensor size** | *Dummy- Dummy*-6 dummy variables to distinguish the size by number of employees from small firms (1-100 employees) to very large organizations (more than 5000 employees). | Amadeus, Lexis Nexis, Osiris |
| **Licensor age** | age of the licensor at the time of survey (2011) | Amadeus, Lexis Nexis, Osiris |
| **Patent pool age** | The age of the pool at the time of the survey (2011) | Patent Pool websites |
| **Patent pool size** | Number of patents included in each patent pool | Patent Pool websites |
| **Pooling experience** | Number of patent pools a company has participated in | Patent Pool websites |
| **Licensor's Bargaining Power** | Number of patents a licensor included in a pool/pool size | Patent Pool websites |
| **Membership duration** | The duration a licensor has participated in each patent pool (years) | Patent Pool websites, EPO Patstat |
| **Vertically integrated (Instrument)** | *dummy*- 1 if a firm with patents and downstream operations manufactures a product dependent on the pool's standard | Companies' websites, 10k |

## Table 6- Descriptive statistics

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| **Priority date** | 2003.931 | 0.786 | 2003 | 2005 |
| **No. of inventors** | 2.691 | 1.845 | 1 | 15 |
| **Licensor size  1-100 empl** | 0.01 | 0.01 | 0 | 1 |
| **Licensor size  100-249 empl** | 0.009 | 0.095 | 0 | 1 |
| **Licensor size  250-499 empl** | 0.007 | 0.08 | 0 | 1 |
| **Licensor size  500-999 empl** | 0.007 | 0.083 | 0 | 1 |
| **Licensor size  1000-4999 empl** | 0.037 | 0.190 | 0 | 1 |
| **Licensor size 5000-9999 empl** | 0.813 | 0.389 | 0 | 1 |
| **Patent pool size** | 2004.2 | 2765.02 | 30 | 10386 |
| **Patent pool age** | 6.55 | 2.603 | 0 | 10 |
| **Pooling experience** | 7.271 | 3.869 | 1 | 15 |
| **Licensor's bargaining power** | .070 | .055 | .0002 | .3914 |
| **Membership durarion** | 6.148 | 2.28 | 0 | 8 |
| **Unused-willing to use** | 0.406 | 0.491 | 0 | 1 |
| **Participation intensity** | 0.173 | 0.193 | 0.0001 | 0.399 |
| **Complementarity** | 0.033 | 0.062 | 0.0004 | 0.570 |
| **Vertically integrated** | 0.838 | 0.372 | 0 | 1 |

## Table 7- Bivariate Correlations Matrix (*N*= *1300*)

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1Priority date** | 1 | | | | | | | | | | | | | | | | | |
| **2 No. of inventors** | .03 | 1 | | | | | | | | | | | | | | | | |
| **3 Licensor size 1-100** | -.03 | .01 | 1 | | | | | | | | | | | | | | | |
| **4 Licensor size 100-249** | .03 | .04 | -.01 | 1 | | | | | | | | | | | | | | |
| **5 Licensor size 250-499** | -.03 | .07** | .01 | -.01 | 1 | | | | | | | | | | | | | |
| **6 Licensor size 500-999** | .01 | .06* | -.01 | -.01 | -.01 | 1 | | | | | | | | | | | | |
| **7 Licensor size 1000-4999** | .06* | .02 | -.02 | -.02 | -.02 | -.02 | 1 | | | | | | | | | | | |
| **8 Licensor size 5000-9999** | .01 | -.06* | -.21*** | -.2*** | -.17*** | -.17*** | -.41*** | 1 | | | | | | | | | | |
| **9 Licensor age** | -.01 | -.13*** | .04 | .07* | -.01 | .03 | -.04 | .04 | 1 | | | | | | | | | |
| **10 Patent pool size** | -.01 | -.04 | -.04 | -.01 | -.02 | -.03 | 0 | .02 | -.23*** | 1 | | | | | | | | |
| **11 Patent pool age** | .01 | .01 | .01 | -.01 | 0 | .03 | .04 | -.05† | .18*** | -.6**** | 1 | | | | | | | |
| **12 Pooling experience** | .01 | 0.1*** | .02 | -.04 | .03 | -.02 | .02 | -.09*** | -.27*** | -.1*** | .13*** | 1 | | | | | | |
| **13 Bargainijng power** | -.06 | 0 | .02 | .03 | -.03 | .02 | -.05 | .04 | .06* | -.31*** | -.02 | -.16**** | 1 | | | | | |
| **14 Membership Duration** | .02 | 0 | .01 | 0 | 0 | .03 | .03 | -.04 | .26*** | -.69*** | .97*** | .07* | .07* | 1 | | | | |
| **15 Unused-willing to use** | .04 | -.06** | -.02 | -.06** | .01 | -.01 | -.01 | .27*** | .03 | -.01 | .03 | 0 | 0 | .04 | 1 | | | |
| **16 Complementarity** | 0 | .02 | .05* | .05* | .01 | -.01 | -.03 | 0 | -.25*** | -.22*** | -.12*** | .38*** | .14**** | -.11*** | .05 | 1 | | |
| **17 Participation intensity** | -.06 | -.08*** | .01 | .09*** | -.02 | 0 | -.01 | .05* | .44*** | .13*** | -.19*** | -.42*** | .25*** | -.12*** | .06** | -.18*** | 1 | |
| **18 Vertically integrated** | .04 | 0 | 0 | .04 | .04 | .01 | 0 | -.03 | .03 | -.19*** | -.04 | -.22*** | .06** | .04 | .05 | .04 | .21*** | 1 |

*** p < 0.001, p** < 0.01, * p < 0.05, † p < 0. 1

## Table 8- Probit estimation - Average marginal effects

| Variables | 1 | 2 | 3 | 4 | IVProbit $1^{st}$ stage | IVProbit $2^{nd}$ stage |
|---|---|---|---|---|---|---|
| **Technological Complementarity** | 0.169** | | 0.678** | 0.668** | 1.554** | 1.554** |
| | (0.072) | | (0.279) | (0.280) | (0.762) | (0.762) |
| **Participation intensity** | 0.451** | | | 0.189** | | 2.409** |
| | (0.224) | | | (0.092) | | (1.051) |
| **Priority date-2004** | | 0.073** | 0.072** | 0.073** | 0.204** | 0.204** |
| | | (0.033) | -0.033 | (0.033) | (0.087) | (0.087) |
| **Priority date-2005** | | 0.036 | 0.039 | 0.043 | 0.154 | 0.154 |
| | | (0.036) | -0.036 | (0.036) | (0.096) | (0.096) |
| **No. of inventors** | | -0.013* | -0.012 | -0.012* | -0.034* | -0.034* |
| | | (0.008) | -0.008 | (0.008) | (0.020) | (0.020) |
| **Licensor size 100-249 empl** | | -0.253* | -0.259* | -0.264* | -1.078 | -1.078 |
| | | (0.116) | (0.113) | (0.108) | (0.615) | (0.615) |
| **Licensor size 250-499 empl** | | 0.153 | 0.181 | 0.180 | 0.430 | 0.430 |
| | | (0.228) | (0.227) | (0.226) | (0.552) | (0.552) |
| **Licensor size 500-999 empl** | | 0.024 | 0.044 | 0.053 | 0.222 | 0.222 |
| | | (0.216) | (0.218) | (0.219) | (0.561) | (0.561) |
| **Licensor size 1000-4999 empl** | | 0.057 | 0.081 | 0.076 | 0.152 | 0.152 |
| | | (0.161) | (0.162) | (0.161) | (0.406) | (0.406) |
| **Licensor size 5000-9999 empl** | | 0.136 | 0.151 | 0.152 | 0.433 | 0.433 |
| | | (0.121) | (0.117) | (0.117) | (0.364) | (0.364) |
| **Licensor age** | | -0.000 | -0.000 | -0.000 | -0.004* | -0.004** |
| | | (0.000) | -0.025 | (0.000) | (0.002) | (0.002) |
| **Pooling experience** | | 0.005 | 0.002 | 0.004 | 0.031 | 0.031** |
| | | (0.004) | -0.004 | (0.004) | (0.016) | (0.016) |
| **Licensor's Bargaining Power** | | -0.057 | -0.124 | -0.303 | -2.276* | -2.276* |
| | | (0.288) | -0.292 | (0.308) | (1.136) | (1.136) |
| **Membership duration** | | 0.074** | 0.081* | 0.072* | 0.106 | 0.106 |
| | | (0.036) | -0.037 | (0.037) | (0.110) | (0.110) |
| **Patent pool size** | | 0.000 | 0.000* | 0.000* | 0.000 | 0.000 |
| ` | | (0.000) | 0 | (0.000) | (0.000) | (0.000) |
| **Patent pool age** | | -0.047 | -0.045 | -0.038 | -0.023 | -0.023 |
| | | (0.029) | -0.029 | (0.029) | (0.089) | (0.089) |
| **Observations** | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| **Pseudo R-squared** | 0.0047 | 0.106 | 0.109 | 0.112 | | |
| **Prob > chi2** | P < 0.05 | P < 0.001 | P < 0.001 | P < 0.001 | | P <0.001 |
| **Log liklihood** | -873.892 | -784.764 | -781.713 | -779.592 | | -115.664 |
| **Wald chi -square** | 8.17 | 63.13 | 65.32 | 69.48 | | 95.09 |
| **Instrument** | Vertically | integrated | | | | |
| **F-value on instruments** | | | | | | 61.24 |
| **Significance of the instrument** | | | | | | P <0.001 |
| **Durbin test of endogeneity** | | | | | | 2.84* |
| **Wu_Hausman** | | | | | | 2.80* |
| **Wald test of exogeneity $\chi^2(1)$** | | | | | | 4.22** |

Notes: Robust standard errors are in parentheses, adjusted for clusters by firms' identifier. All models include dummies for missing values for licensor size. *p<0.1, ** p<0.05, *** p<0.000

## Table 9-Weak instrument robust tests and confidence sets for IV probit

**H0: β[Unused but willing to use :participation intensity] = 0**

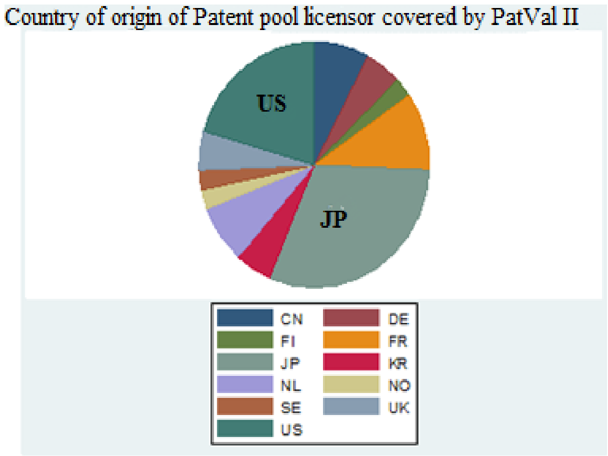
| Test | Statistic | p-value | Conf. level | Conf. Set |
|---|---|---|---|---|
| AR | chi2(1) = 4.43 | 0.0353 | 95% | [.237572,5.09323] |
| Wald | chi2(1) = 4.22 | 0.0399 | 95% | [.11618, 4.92329] |

## Table 10-LPM and IVRegress- *Dependent Variable is Unused but willing to use*

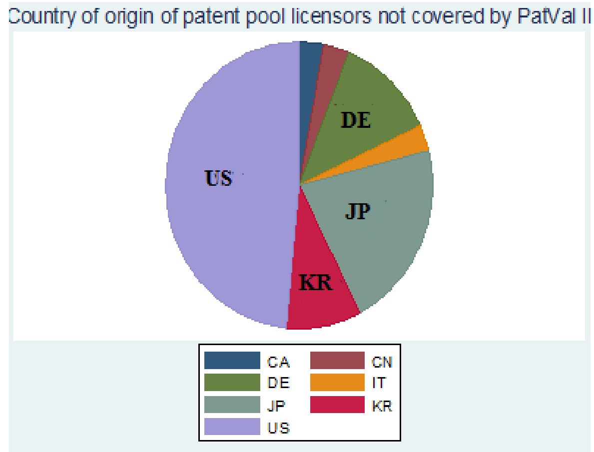
| Variables | LPM | IVRegress 1st stage | IVRegress 2nd stage |
|---|---|---|---|
| **Technological Complementarity** | 0.615** | 0.0671 | 0.556** |
| | (-0.246) | (0.0803) | (0.262) |
| **Participation intensity** | 0.179** | | 0.843** |
| | (-0.088) | | (0.413) |
| **Priority date-2004** | 0.068* | -0.009 | 0.073** |
| | (-0.03) | (0.009) | (0.031) |
| **Priority date-2005** | 0.036 | -0.024 | 0.050 |
| | (-0.034) | (0.010) | (0.035) |
| **No. of inventors** | -0.012 | 0.001 | -0.013* |
| | (-0.007) | (0.002) | (0.007) |
| **Firm size 100-249 empl** | -0.264 | .068 | -0.315 |
| | (-0.156) | (.058) | (-0.193) |
| **Firm size 250-499 empl** | 0.17 | -.009 | 0.167 |
| | (-0.211) | (.063) | (-0.206) |
| **Firm size 500-999 empl** | 0.048 | -.048 | 0.08 |
| | (-0.203) | (.063) | (-0.206) |
| **Firm size 1000-4999 empl** | 0.073 | .0195 | 0.06 |
| | (-0.146) | (.045) | (-0.149) |
| **Firm size 5000-9999 empl** | 0.165 | -.005 | 0.17 |
| | (-0.128) | (.041) | (-0.132) |
| **Licensor age** | 0.000 | 0.002*** | -0.001 * |
| | (0.000) | (0.0001) | (0.001) |
| **Pooling experience** | 0.004 | -0.0089 | 0.011* |
| | (-0.004) | (0.0012) | (0.006) |
| **Bargaining power** | -0.197 | 0.924*** | -0.743* |
| | (-0.256) | (0.0852) | (0.435) |
| **Membership duration** | 0.070* | 0.023** | 0.041* |
| | (-0.034) | (0.011) | (0.039) |
| **Patent pool size** | 0.000* | 0.000*** | 0.000* |
| ` | (0.000) | (2.57E-06) | (0.000) |
| **Patent pool age** | -0.037 | -0.020304 | -0.011 |
| | (-0.027) | (0.0087) | (0.032) |
| **Observations** | 1300 | 1300 | 1300 |
| **R-squared** | 0.0.1137 | 0.4341 | 0.0732 |
| **Prob > F** | P <0.001 | P <0.001 | P <0.001 |
| **Wald chi -square** | - | 95.09 | 159.57 |

Notes: Robust standard errors are in parentheses, adjusted for clusters by firms' identifier.
All models include dummies for missing values for licensor size. *p<0.1, ** p<0.05, *** p<0.0

**Graph1: Country of origin of patent pool licensors covered by PatVal II (N= 37)**




**Graph2: Country of origin of patent pool licensors not covered by PatVal II (N= 37)**




## Graph 3- Patent pool participation

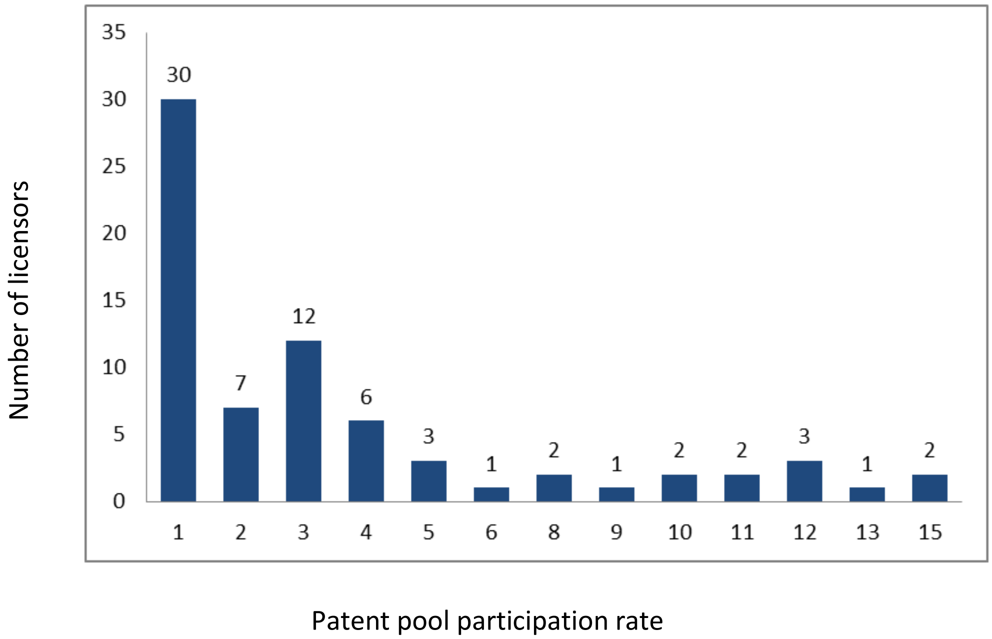


**Table A– Patent pools in our working sample**

| | Patent pool | No. of non-pooled patents | No. of licensors participated |
|---|---|---|---|
| 1 | 3G G.711.1 | 2 | 1 |
| 2 | 3G W-CDMA | 483 | 5 |
| 3 | Mpegla AVC | 13 | 4 |
| 4 | Mpegla MPEG-2 Systems | 4 | 1 |
| 5 | Mpegla MPEG-4 Systems | 1 | 1 |
| 6 | Mpegla MPEG-4 Visual | 102 | 10 |
| 7 | Mpegla MVC | 259 | 13 |
| 8 | Mpegla VC-1 | 171 | 11 |
| 9 | One Blue | 115 | 5 |
| 10 | Sisvel DVB-T | 16 | 1 |
| 11 | Sisvel DVB-T2 | 7 | 2 |
| 12 | Sisvel H.264 SVC | 15 | 1 |
| 13 | Uldage ARIB | 44 | 5 |
| 14 | Uldage CATV Compliant | 47 | 8 |
| 15 | Uldage CATV Essential | 21 | 4 |

# CONCLUSION

The central concern of this thesis is patent nonuse particularly from strategic point of view; when a patent is not used due to pure strategic purposes or inhibits the use of other inventions which can be employed as better alternative solutions within the market for technology. While the literature has investigated some drivers for strategic patenting, the welfare effect of strategic patenting as well as the solutions to tackle issues caused by strategic patenting, there is still clear lack of theory explaining (1) the managerial decision making process for strategic use of patents and (2) how to assess welfare effect of strategic patenting and (3) a comprehensive solutions to tackle issues caused by strategic blocking patents and benchmark to assess their effectiveness.

Moreover, while there exists few empirical studies that have distinguished between used and unused strategic patents (e.g. Torrisi et al., 2014) no study has investigated the divers of unused play patents as a particular type of strategic patents. In addition, while the current literature has emphasized on the role of patent pools in dealing with potential issues such as excessive transaction cost caused by patent thickets and blocking patents (overlapping IPRs) that might hamper the use of patents in the market for technology, no study has investigated the role of patent pools perceived by companies in facilitating technology commercialization and favoring the use of patents. This thesis sheds light on the factors explaining unused play patents by identifying technological uncertainty and technological complexity as two technology environment drivers for this type of unused patents. Furthermore, this thesis investigates the association between participation intensity in patent pools and the willingness to use non-pooled patents through pool participation by pool members. Moreover, it uncovers those characteristics of patent pools in complex technological fields that can explain the willingness to use a non-pooled patent by a pool member through pool participation. This thesis contributes to the literature on strategic management of IPRs by examining the underlying technological mechanisms leading to patent nonuse. It also contributes to the current discussion on social, economic and technological benefits of patent pools. The results of this thesis have practical implications for strategic decision-making and for policy makers dealing with the issue of patent nonuse, overlapping IPRs and cumulative innovations.